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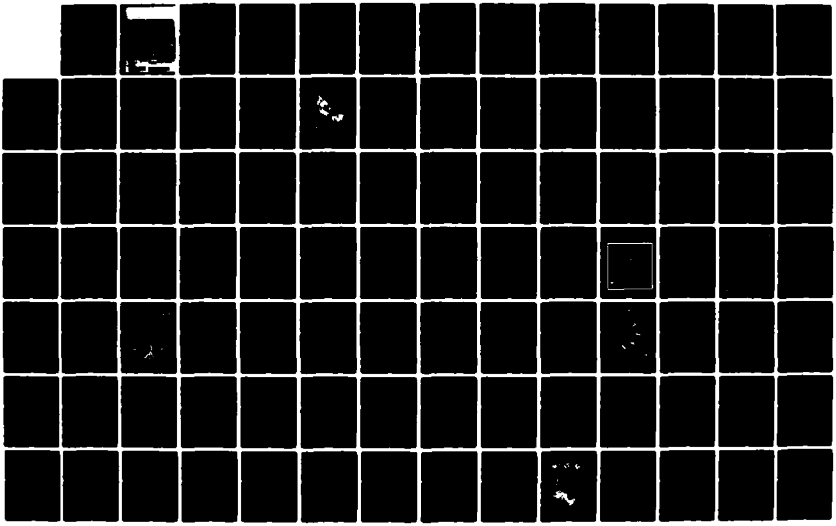

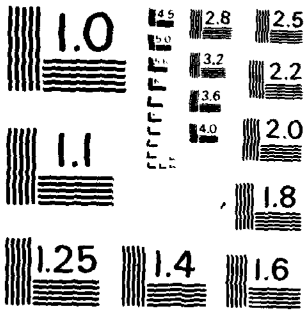

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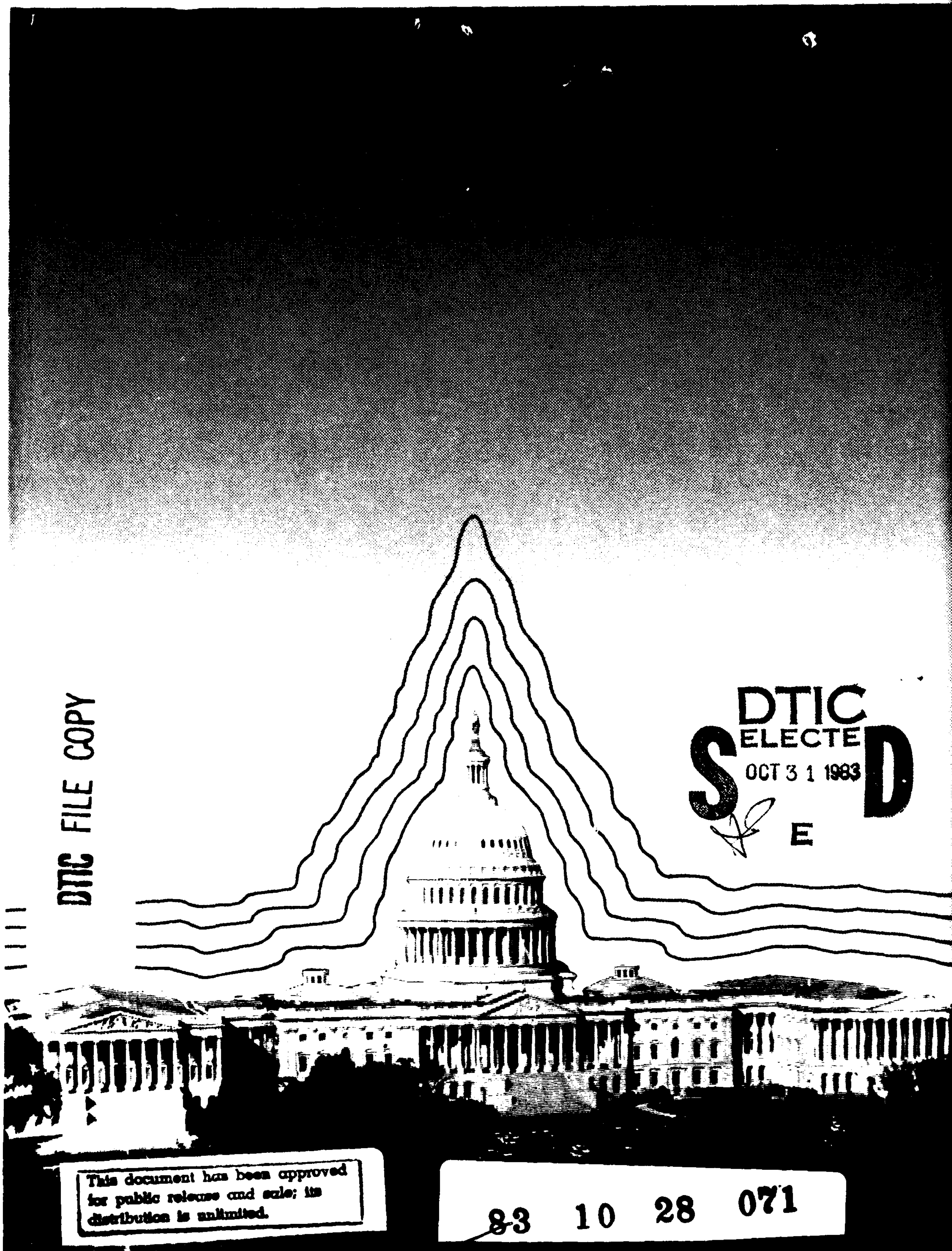

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METROPOLITAN WASHINGTON AREA
WATER SUPPLY STUDY

APPENDIX I
OUTLYING SERVICE AREAS

Department of the Army
Baltimore District, Corps of Engineers
Baltimore, Maryland

September 1983

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In response to the Water Resources Development Act of 1974, the Baltimore District of the U.S. Army Corps of Engineers conducted a comprehensive water supply analysis of the Metropolitan Washington Area (MWA). Severe water supply shortages had been forecast for the MWA and the study was undertaken to identify and evaluate alternative methods of alleviating future deficits. Initiated in 1976, the study was conducted in two phases over a 7-year period. The first, or early action phase, examined the most immediate water supply problems and proposed solutions that could be implemented locally. The second or long

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water shortage; reregulation; finished water interconnection; Occoquan Reservoir; Patuxent Reservoir; Potomac Estuary; Water Supply Coordination Agreement; Verona Lake

20. ABSTRACT (continued)

range phase included an analysis of the full spectrum of structural and nonstructural water supply alternatives. In addition to such traditional water supply alternatives as upstream reservoir storage, groundwater and conservation, the study also considered such innovative measures as wastewater reuse, raw and finished water interconnections between the major suppliers, the use of the upper Potomac Estuary, reregulation and water pricing. A key tool in the study was the development and use of a basin-specific model that was used to simulate the operation of all the MWA water supply systems and sources under various drought scenarios. As the study progressed, local interests used the technical findings of the Corps' study to make great strides toward a regional solution to their water supply problems. The Corps' study concluded that with the implementation of a series of regional cooperative management agreements, contracts, selected conservation measures, and the construction of one local storage project to be shared by all, severe water supply shortages could effectively be eliminated for the next 50 years. The Final Report of the study is comprised of eleven volumes which provide documentation of both the study process and the results of all the technical analyses conducted as part of the study.

REPORT ORGANIZATION*

METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY

Appendix Letter	Appendix Title	Annex Number	Annex Title
	Main Report		
A	Background Information & Problem Identification		
B	Plan Formulation, Assessment, and Evaluation	B-I	Water Supply Coordination Agreement
		B-II	Little Seneca Lake Cost Sharing Agreement
		B-III	Savage Reservoir Operation and Maintenance Cost Sharing Agreement
C	Public Involvement	C-I	Metropolitan Washington Regional Water Supply Task Force
		C-II	Public Involvement Activities - Initial Study Phase
		C-III	Public Opinion Survey
		C-IV	Public Involvement Activities - Early Action Planning Phase
		C-V	Sample Water Forum Note
		C-VI	Public Involvement Activities - Long-Range Planning Phase
		C-VII	Citizens Task Force Resolutions
		C-VIII	Background Correspondence
		C-IX	Coordination with National Academy of Sciences - National Academy of Engineering
		C-X	Comments and Responses Concerning Draft Report
D	Supplies, Demands, and Deficits	D-I	Water Demand Growth Indicators by Service Areas
		D-II	Service Area Water Demand & Unit Use by Category (1976)
		D-III	Projected Baseline Water Demands (1980-2030)
		D-IV	Potomac River Low Flow Allocation Agreement
		D-V	Potomac River Environmental Flowby, Executive Summary
		D-VI	PRISM/COE Output, Long-Range Phase
E	Raw and Finished Water Interconnections and Reregulation	E-I	Special Investigation, Occoquan Interconnection Comparison
F	Structural Alternatives	F-I	Digital Simulation of Groundwater Flow in Part of Southern Maryland
G	Non-Structural Studies	G-I	Metropolitan Washington Water Supply Emergency Agreement
		G-II	The Role of Pricing in Water Supply Planning for the Metropolitan Washington Area
		G-III	Examination of Water Quality and Potability
H	Bloomington Lake Reformulation Study	H-I	Background Information
		H-II	Water Quality Investigations
		H-III	PRISM Development and Application
		H-IV	Flood Control Analysis
		H-V	US Geological Survey Flow Loss and Travel Time Studies
		H-VI	Environmental, Social, Cultural, and Recreational Resources
		H-VII	Design Details and Cost Estimates
		H-VIII	Drawdown Frequency and Yield Dependability Analyses
		H-IX	Bloomington Future Water Supply Storage Contract
		H-X	Novation Agreement
I	Outlying Service Areas		

*The Final Report for the Metropolitan Washington Area Water Supply Study consists of a Main Report, nine supporting appendices, and various annexes as outlined above. The Main Report provides an overall summary of the seven-year investigation as well as the findings, conclusions, and recommendations of the District Engineer. The appendices document the technical investigations and analyses which are summarized in the Main Report. The annexes provide detailed data or complete reports about individual topics contained in the respective appendices.

METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY

APPENDIX I - OUTLYING SERVICE AREAS

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APPENDIX I - OUTLYING SERVICE AREAS

INTRODUCTION

This Appendix addresses the future water supply needs of the four water service areas in the Metropolitan Washington Area that lie outside the area dependent on the Potomac River as source of water supply. These areas are shown in Figure I-1 and include the Fairfax City Service Area, the Loudoun County Service Area, the Prince William County Service Area, and the Charles County Service Area. The boundaries of these service areas represent the geographical limits of the areas potentially served by public systems by the year 2030. For convenience, four distinctive outlying areas have been identified, however, it is noted that each of these areas are comprised of numerous smaller individual and independent utilities. These areas provide about 5% of the total treated water in the MWA and they do not currently use the Potomac River as a source of water supply. This relationship is due largely to the low population density and more rural character of the outlying areas, as compared to the areas in the urban core. It is anticipated however that these areas will experience developmental pressures and acccompanying population increases from the expanding urban center of Washington D.C. and will continue to grow appreciably through the year 2030. Continued growth will place increasing pressure on these areas to meet growing water demands.

The purpose of this Appendix is to define the extent of the water supply needs in these outlying areas and to present some potential projects or actions that the local jurisdictions might initiate to meet those needs. The projects presented here, if initiated, would not require Federal involvement or Congressional authorization. Since these actions involve single purpose water supply they would be funded entirely by local interests. Because the outlying service areas constitute a relatively minor portion of the overall MWA water supply needs and because of the absence of the Federal interest in solving their problems it was determined that a "less then feasibility scope" level of detail was appropriate for this part of the study. As such, this Appendix does not contain any specific recommendations for the service areas investigated. Instead, a prioritization of potential solutions is offered with a discussion of the advantages and disadvantages of any actions that might be undertaken locally. This document should assist local planners in understanding the future needs of their communities and the relative potential of alternative projects or actions to meet those needs. A more detailed planning investigation would be required prior to implementation of any of the alternatives discussed in this Appendix.

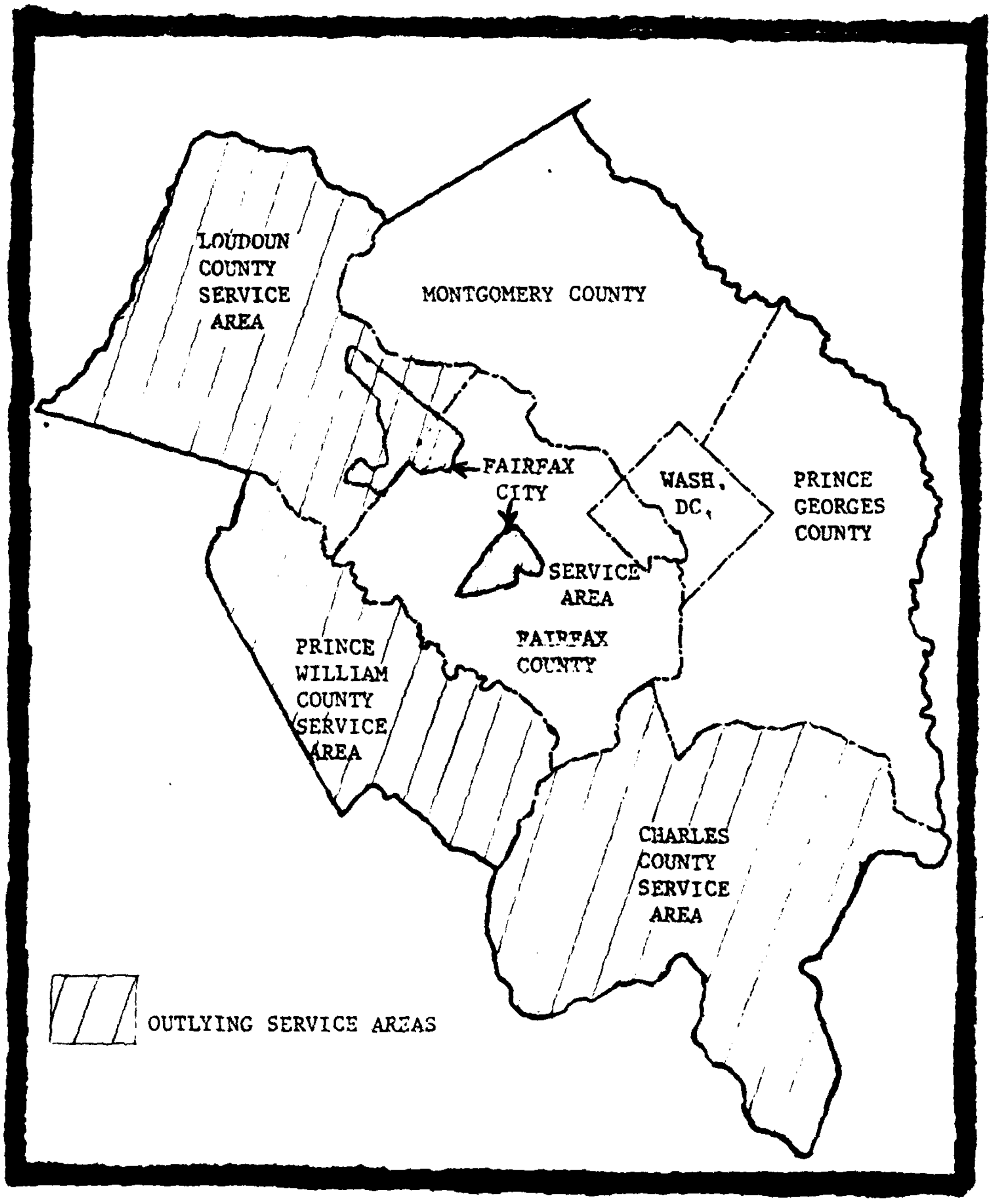
DEVELOPMENT OF POPULATION AND DEMAND PROJECTIONS

POPULATION GROWTH

During the last 50 years, the MWA urban core has experienced increasing development and areal expansion due primarily to inter-related increases in government, employment, and housing. Despite this continuing growth and development, the urban area's share of total MWA population declined slowly and a perceptible increase in the share of the total population was occurring in the less urban (perhaps even rural) areas on the perimeter of the MWA - Charles, Loudoun, and Prince William Counties. Indeed, large amounts of growth had to occur in these outlying areas to effect a change in the proportion of total population. This did take place as evidenced by the recognition of Prince William County

FIGURE I-1

LOCATION MAP - OUTLYING SERVICE AREAS



as the fastest growing large county in the MWA during the 1960-1970 period. While the shift in population shared between the urban and outlying areas had been gradual to 1970, the 1980 Census indicated a pronounced change. The outlying areas had increased their proportion of MWA population by almost three percent - more than double any previous ten year share increase. Reasons for this shift in shares are several including: curtailed commuting time brought by interstate highway and state road development; growth constraints in the more urbanized areas such as sewer and water moratoria; increased concern given environmental issues through watershed planning, land use planning, and zoning activities; and differences in costs of living as illustrated by the affordability and availability of housing in the outlying areas.

Growth and development is expected to continue in the outlying areas. Beyond 1990, growth will become more pronounced because as the urban center expands outward so will the employment centers and resultant job opportunities. The development and operation of mass transportation facilities will also be a factor in these "perimeter" counties.

As growth and development progress in the outlying areas, no doubt situations will arise similar to those experienced in the older, more urban areas of the MWA. An increased need for and reliance on public utility provision will manifest itself. One of these utility services is potable water supply and delivery. As new growth occurs, increased demand for water will bring with it the need for increased reliability of water delivery. The following sections present projections of population and water demands for the outlying areas and discusses the methodology used to arrive at these projections. The discussion traces the various data which were examined, modified, and then used as a basis for the projections made for the outlying service areas.

The population projections for the outlying service area are based on revised data which has become available subsequent to the publications of the early-action report of August 1979. Appendix D, Supplies, Demands and Deficits contains a complete description of the population projection methodology as well as the methodologies used in projecting households and employment, the phasing of subareas to be publically served over the planning horizon, basic water use characteristics, and the demand projection computer program. The basic methodologies and some of the base data used in the early-action report remain applicable and were used in the revision of service area demands for the outlying areas. The following sections discuss the revision of demands for the outlying areas based on the introduction of new base data and the reasons for the departure from the projections originally used in the early-action phase of the study.

METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS (MWCOG) ROUND II PROJECTIONS

In the spring of 1979, MWCOG released a revised series of demographic projections referred to as Round II - Cooperative Forecasts which are shown in Table I-1. These forecasts reflected an overall growth rate for the MWA which was less then the Round I forecasts released three years previously and used in the Corps early-action report. MWCOG population projections were used as a basis for growth estimates for the entire MWA Water Supply Study because they reflect an accurate and regionally supported data base used for regionwide planning. This is discussed in further detail in Appendix D, Supplies, Demands and Deficits. More importantly, in considering further analysis for

TABLE I-1

MWCOG COOPERATIVE POPULATION FORECASTS - ROUND II

(000's)

	1970	1977	1980	1985 Low	1985 IM	1985 High	1990 Low	1990 IM	1990 High	1995 Low	1995 IM	1995 High	2000 Low	2000 IM	2000 High
District of Columbia	756.5	691.5	702	715	724	734	722	734	746	720	734	748	718	733	751
Arlington County	174.3	162.9	168	176	179	181	183	189	194	189	198	205	194	206	215
Alexandria City	110.9	115.8	121	126	128	140	131	134	148	133	136	154	134	138	154
Core	1041.7	970.2	991	1017	1031	1055	1036	1057	1088	1042	1068	1107	1046	1077	1120
Montgomery County	522.8	593.5 [1]	600	614	639	683	642	690	748	667	747	806	692	790	866
Prince George's County	660.6	672.1	673	702	715	729	738	781	809	770	824	872	790	871	931
Fairfax County	455.0	573.2	627	699	708	713	744	781	828	788	865	922	819	950	1005
Falls Church City	10.8	9.8	9.0	9.3	9.5	9.7	9.4	9.9	10.4	9.6	10.3	10.6	9.8	10.8	11.0
Fairfax City	22.0	21.6	21.9	22.0	22.8	23.1	22.8	23.7	24.0	24.0	24.6	25.4	24.8	25.2	26.0
Inner Suburban Ring	1671.2	1870.2	1931	2046	2095	2158	2156	2286	2419	2259	2471	2636	2336	2647	2839
Loudoun County	37.0	58.5	68	72	94	112	82	116	174	95	138	199	103	160	224
Prince William County	95.1	144.2	161	190	194	226	193	225	253	195	253	281	199	278	307
Independent Cities[2]	16.0	21.8	24	28	29	29	32	33	33	33	37	38	34	40	44
Outer Suburban Ring	148.1	224.5	253	290	317	367	307	374	460	323	428	518	336	478	575
Region	2861	3065	3175	3353	3443	3580	3499	3717	3967	3624	3967	4261	3718	4202	4534

[1] January, 1978
[2] Manassas and Manassas Park
Source: Cooperative Forecasting, Round Two Summary Report - 1979; Metropolitan Washington Council of Governments, December 1979.

the outlying areas the newly released data indicated that a larger share of MWA population would be locating in the fringe areas surrounding the urban core. Whereas the overall regional Round II forecast was lower then Round I, the Round II forecasts for the outlying area exceeded those of the Round I forecasts (Table I-2). Because of this projection of increased growth for these areas, it was appropriate to revise the projections for the outlying areas which were originally based on Round I data. Subsequent to MWCOG forescasts, population estimates for 1980 based on results of the 1980 Census were released. These Census results indicated that growth was occurring at a rate even less than that implied in the Round II forecasts. Therefore, to revise the 1978 estimates of growth in the outlying areas several things were done. The 1979 Round II projections were adjusted downward by a fixed percentage to reflect the difference between the Round II forecast of 1980 population and the actual 1980 population figures provided by the Bureau of the Census. The result of this effort based on 1980 Census data was a lowering of the regional Round II projections by approximately six percent.

EXTENSION OF MWCOG PROJECTIONS TO YEAR 2030

The next step was to extend these projections (1980-2000) to the year 2030. The procedure employed was the same described in Appendix D. The Bureau of Economic Analysis (BEA) five-year growth ratios (Table D-15) were applied to extend the population forecasts to the year 2020 and then a regression was used to obtain a point estimate for the year 2030. This procedure produced a revised set of regional projections to the year 2030. The regional estimates were then disaggregated to the political jurisdictions (county, town or city) by relating these shares of growth to the total region. The resulting projections are presented in Figure I-2. The figure shows significant growth in the outlying counties - approximately a four-fold increase over the 1980-2030 planning horizon.

PHASING OF SUBAREAS TO BE SERVED BY PUBLIC SYSTEMS

After developing county wide and regional population projections, it was necessary to determine the degree by which communities within the outlying areas would likely be served by public water systems during the period 1980-2030. Figure D-30 of the Supplies, Demands and Deficits Appendix and the accompanying text describe the approach used in the early-action phase to determine areas to be publicly served. Because the MWCOG Round II population projections estimated a significant shift and increase in the rate of growth for these outlying areas as compared to earlier Round I forecasts, it also became necessary to rephase areas to be served to better reflect the more recent estimates for growth within the region. This was accomplished by revisiting county planners in Prince William, Loudoun and Charles Counties in late 1980 and early in 1981 to determine how they felt growth would likely occur in the future. Using their inputs on short term and long term growth patterns as well as land use planning maps, capital improvement plans, and published growth plans, newly developed MWCOG Transportation Analysis Zones (which accompanied the Round II forecasts) were aggregated for each bench mark year to develop and define the growth patterns of the Loudoun County, Prince William County and Fairfax City Service Areas (Figure I-3). This task was accomplished in-house. Because Charles County was not included as part of the MWCOG forecasts, census tracts were used as the areal units for phasing for this service area.

Table I-2

MWCOG
Comparison of Population Projections for Outlying Counties - MWCOG Round I vs Round II
(1000's)

	1980		1985		1990		1995	
	I[1]	II[2]	I	II	I	II	I	II
Charles Co., MD[3]	62	73	71	84	76	98	82	108
Prince William Co., VA	179	145	198	223	218	258	236	290
Loudoun Co., VA	61	57	74	94	89	116	102	138
Fairfax City, VA	22	19	22	23	22	24	22	25
TOTALS	324	294	365	424	405	496	442	561

[1]Value given in Table for 1980 based on population data available in 1976 and 1977.
[2]Reflects 1980 Census figures; figures for 1985, 90, 95 represent Round II - Intermediate forecasts.
[3]Charles Co. projections based on MD Dept. State Planning letter, April 10, 1980.

FIGURE I-2

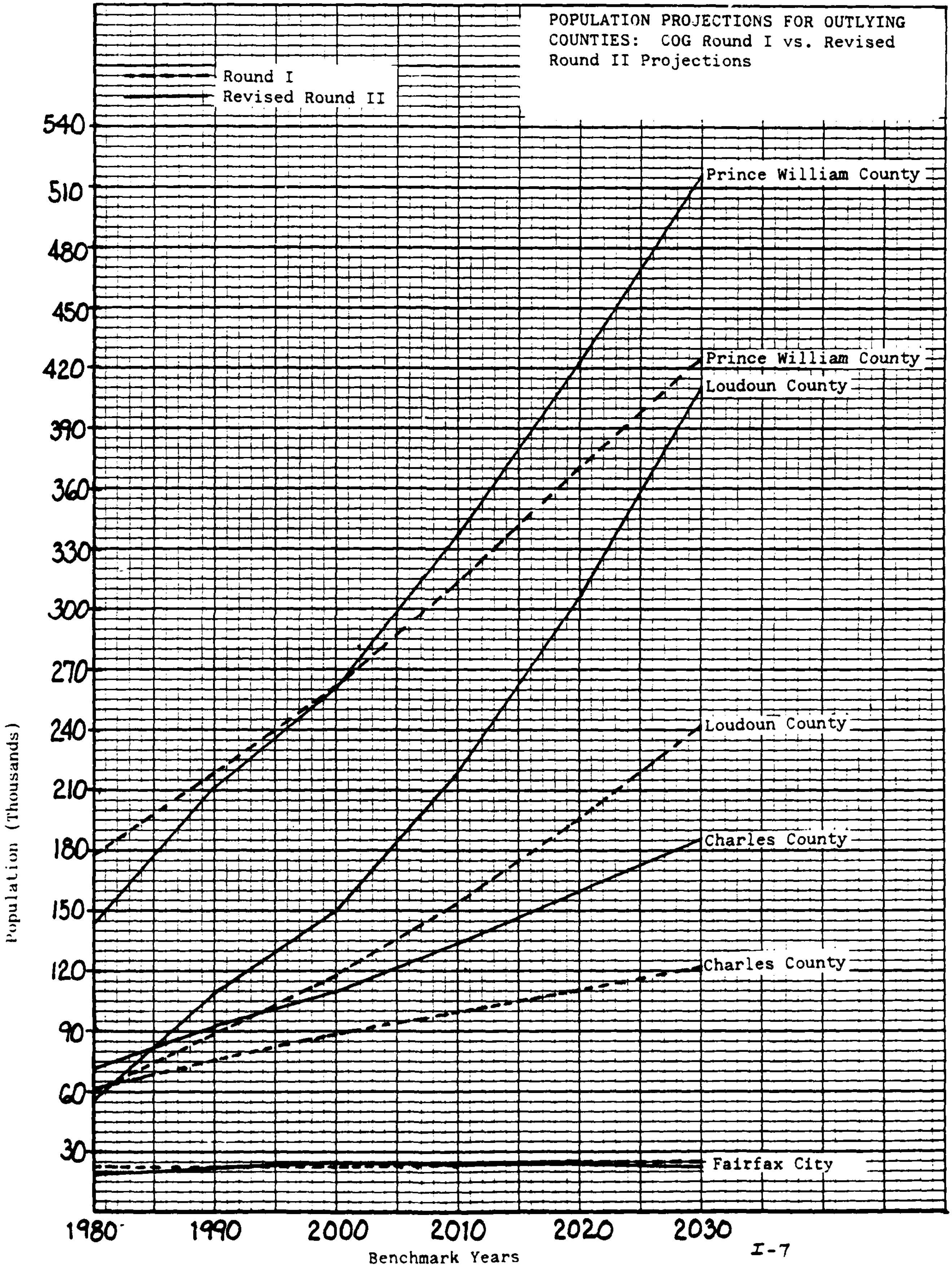
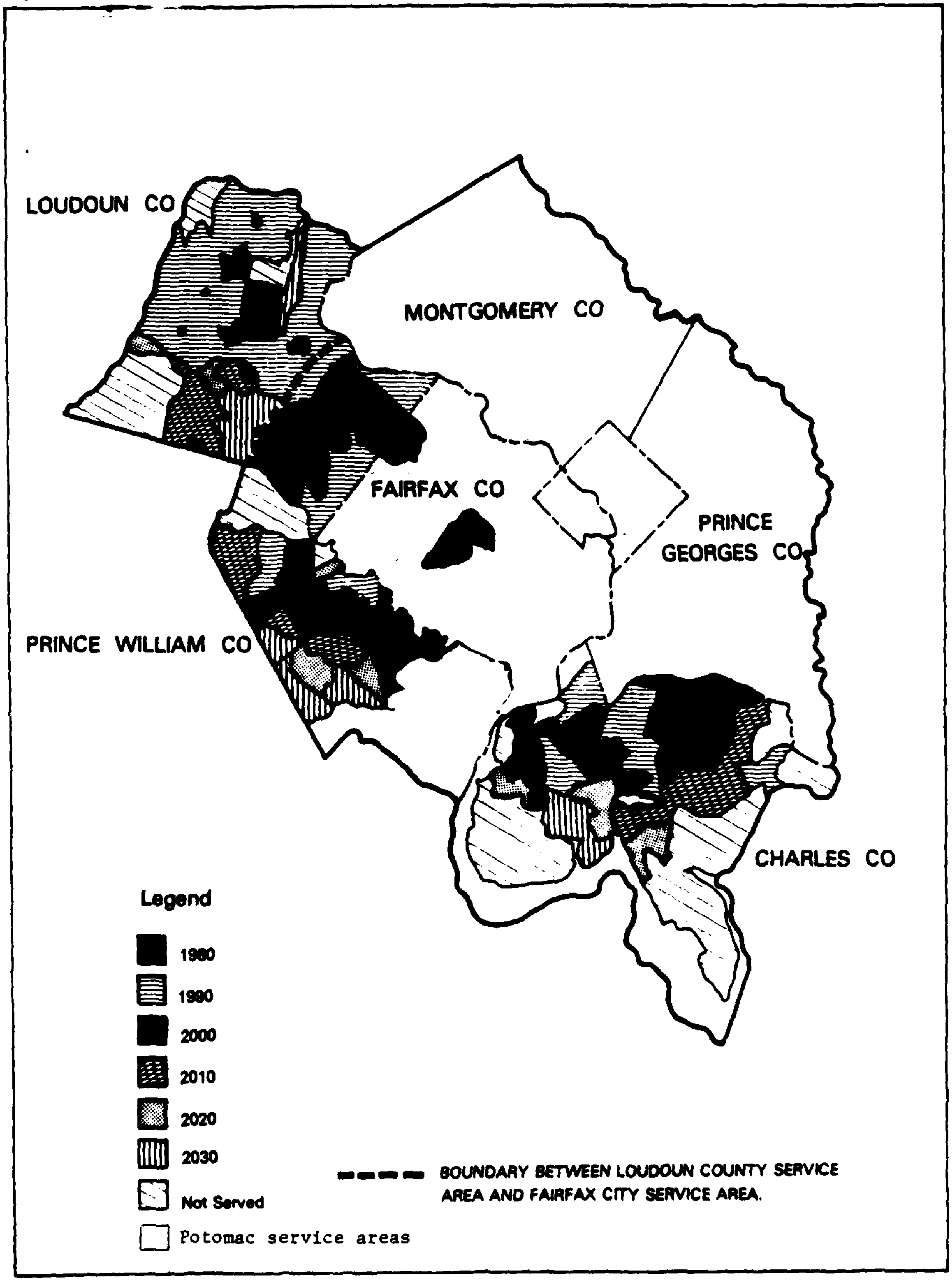

POPULATION PROJECTIONS FOR OUTLYING COUNTIES: COG Round I vs. Revised Round II Projections
Round I
Revised Round II
540
510
480
450
420
390
360
330
300
270
240
210
180
150
120
90
60
30
Population (Thousands)
Prince William County
Prince William County
Loudoun County
Loudoun County
Charles County
Charles County
Fairfax City
1980
1990
2000
2010
2020
2030
Benchmark Years

Figure I-3 PHASING OF AREAS TO BE SERVED BY PUBLIC SYSTEMS



WATER USE DATA

Another important input required in the MWA demand projection model was water use. Water use base data were collected for all of the MWA service areas using 1976 water use information (See Table D-19, Supplies, Demands and Deficits Appendix). A summary of selected data for the outlying areas which was developed as part of 1976 survey of water use is summarized in Table I-3. Only the service area totals, which represent the total of the existing communities water use in 1976, were used as inputs in the demand model.

In order to demonstrate the impact of the seasonality of water use demands over a yearly period which would more accurately depict actual demand patterns as they might occur, average monthly demand distribution factors were developed. These factors were calculated initially for the FCWA, WAD, and WSSC service areas using daily pumpage and/or water treatment plant production records for the period 1968-1976. A full description of the development of these factors is contained in Appendix D. For the purposes of this analysis average monthly demand distribution factors developed for major Potomac users were assigned to the outlying service areas based on the similarity of development patterns. These factors are summarized in Table I-4.

As a further refinement in the demand projections, additional inputs pertaining to the number of dwelling units, employment projections, and indoor versus outdoor water use in the residential section were developed as explained in Appendix D. These refinements resulted in a rather sophisticated projection of monthly and average annual demands based not solely on population, but other important socio-economic factors which influence the demand for water as well.

DEMAND PROJECTIONS

Several output tables from the demand model are presented as Tables I-5 through I-12 for each of the outlying service areas using the revised data inputs. Table I-5, 6, 7 and 8 summarize the baseline average annual demands by water use category projected over the planning period. In all cases, the data show that the great majority of the demand is in the residential sectors and that its proportion of the overall demand is growing during the planning period.

Tables I-9, 10, 11, and 12 illustrate the monthly changes in the demand for water with the greatest demand during the summer months of June, July, August and September and the smallest during the winter months. This is expected since the majority of use in these areas is in the residential sector where outdoor use during the summer results in an increase in consumption over and above that normally associated with indoor use. Table I-13 and Figure I-4 represent a composite summary of the average annual demands projected for the outlying areas. In all cases, demands projected for the 50-year planning period are expected to increase dramatically. In the cases of Fairfax City, Prince William County and the Charles County service areas the demands expected to be placed on public systems will quadruple by the year 2030 and in the case of Loudoun County will increase by a factor of over sixteen. In Figure I-4 a broken scale relationship is provided to show the average annual demand curve for the Potomac River users as a basis for comparison with the outlying areas. Despite the fact that the aggregate demands for the outlying areas represent only a very small part of the overall regional needs, the rate of increase in the smaller areas warrants concern because existing facilities will not be capable of handling these additional needs.

TABLE I-3

WATER USE IN OUTLYING SERVICE AREAS, 1976 (MGD)

		Single Fam	Multi Fam	Comm/Ind	Gov't/Inst	Unacc.	Totals
Fairfax City Service Area	LCSA	1.328	.073	.207	0.	.332	1.940
	Fx/Cty	1.727	.806	.516	.190	1.410	4.649
	Town of Herndon	.410	.316	.131	0.	.153	1.010
	TOTAL	3.465	1.195	.854	.190	1.895	7.599
Loudoun Co. Service Area	Town of Leesburg	.532	.058	.110	.024	.118	.842
	Loudoun Co. Loells & Springs	.521	.057	.108	.008	.113	.807
	Total	1.053	.115	.218	.032	.231	1.649
Charles Co. Service Area	Charles Co. DPW	.692	.145	.175	.021	.168	1.201
	Indian Head DPN	.158	.011	.031	.025	.034	.259
	LaPlata DPW	.132	.030	.016	.024	.031	.233
	Total	.982	.186	.222*	.07*	.233	1.693
Prince William Co. Service Area	City of Manassas	.648	.170	.568	.079	.100	1.565
	City of Manassas Park	.23	0.	.03	0.	.03	.29
	Greater Manassas Sanitary Dist.	1.14	.29	.14	.05	.24	1.86
	Quantico Mar.	.001	0.	.001	2.464	.435	2.901
	Town of Quantico	.005	.021	.019	0.	.005	.050
	PW Co. Wells	.200	0.	.020	.006	.034	.260
	Total	2.224	.481	.778	2.599	.844	6.926

*These totals also include a component of Federal water use not individually cited in table.

TABLE I-4

AVERAGE MONTHLY DEMAND DISTRIBUTION
FACTORS APPLIED TO OUTLYING WATER SERVICE AREAS

Month	Prince William(1)	Loudoun(1)	Fairfax City(1)	Charles(2)
Jan	0.888	0.888	0.888	0.907
Feb	0.888	0.888	0.888	0.908
Mar	0.892	0.892	0.892	0.909
Apr	0.967	0.967	0.967	0.954
May	1.026	1.026	1.026	1.023
Jun	1.099	1.099	1.099	1.109
Jul	1.176	1.176	1.176	1.154
Aug	1.122	1.122	1.122	1.108
Sep	1.076	1.076	1.076	1.108
Oct	0.982	0.982	0.982	0.983
Nov	0.948	0.948	0.948	0.943
Dec	0.936	0.936	0.936	0.925

1 Monthly Demand Distribution Factors are based on actual data provided by the FCWA.

2 Monthly Demand Distribution Factors are based on actual data provided by the WSSC.

TABLE I-5

FAIRFAX CITY DEMAND AREA - BASELINE
AVERAGE ANNUAL DEMANDS BY USER
CATEGORY

TIME HORIZON	SINGLE FAMILY (MGD)	MULTI-FAMILY (MGD)	COMMERICAL/ INDUSTRIAL (MGD)	GOVERNMENTAL/ INSTITUTIONAL (MGD)	FEDERAL GOVERNMENT (MGD)	UNACCOUNTED FOR USE (MGD)	TOTAL USE (MGD)
1976	3.465	1.195	.849	.190	.005	1.895	7.599
1980	3.588	3.246	1.004	.234	.006	2.683	10.761
1990	4.646	5.134	1.331	.402	.008	3.827	15.348
2000	5.361	6.240	1.563	.574	.009	4.733	18.979
2010	7.158	7.980	1.982	.735	.011	5.935	23.801
2020	8.560	10.528	2.534	.946	.014	7.503	30.086
2030	10.325	13.209	3.153	1.107	.017	9.266	37.157

TABLE I-6

LOUDOUN COUNTY DEMAND AREA - BASELINE
AVERAGE ANNUAL DEMANDS BY USER
CATEGORY

TIME HORIZON	SINGLE FAMILY (MGD)	MULTI-FAMILY (MGD)	COMMERICAL/ INDUSTRIAL (MGD)	GOVERNMENTAL/ INSTITUTIONAL (MGD)	FEDERAL GOVERNMENT (MGD)	UNACCOUNTED FOR USE (MGD)	TOTAL USE (MGD)
1976	1.053	.115	.218	.026	.006	.231	1.649
1980	1.058	.407	.392	.047	.010	.312	2.226
1990	3.008	1.377	1.345	.194	.031	.970	6.925
2000	4.561	2.195	2.396	.382	.048	1.561	11.143
2010	6.898	3.466	4.024	.643	.081	2.462	17.574
2020	9.725	5.128	6.227	.996	.125	3.616	25.817
2030	13.589	7.495	9.316	1.491	.188	5.225	37.303

TABLE I-7

PRINCE WILLIAM COUNTY DEMAND AREA - BASELINE AVERAGE ANNUAL DEMANDS BY USER CATEGORY

TIME HORIZON	SINGLE FAMILY (MGD)	MULTI-FAMILY (MGD)	COMMERICAL/ INDUSTRIAL (MGD)	GOVERNMENTAL/ INSTITUTIONAL (MGD)	FEDERAL GOVERNMENT (MGD)	UNACCOUNTED FOR USE (MGD)	TOTAL USE (MGD)
1976	2.224	.481	.778	.135	2.464	.844	6.926
1980	1.572	.408	.738	.120	2.039	.677	5.553
1990	3.001	.760	1.199	.186	2.326	1.037	8.509
2000	3.951	1.086	1.743	.259	2.451	1.317	10.806
2010	5.157	1.589	2.489	.370	2.599	1.694	13.899
2020	6.421	2.249	3.427	.509	2.674	2.121	17.401
2030	7.949	3.123	4.486	.669	2.703	2.627	21.557

TABLE I-8

CHARLES COUNTY DEMAND AREA - BASELINE
AVERAGE ANNUAL DEMANDS BY USER
CATEGORY

TIME HORIZON	SINGLE FAMILY (MGD)	MULTI-FAMILY (MGD)	COMMERCIAL/ INDUSTRIAL (MGD)	GOVERNMENTAL/ INSTITUTIONAL (MGD)	FEDERAL GOVERNMENT (MGD)	UNACCOUNTED FOR USE (MGD)	TOTAL USE (MGD)
1976	.982	.186	.204	.046	.042	.233	1.693
1980	1.340	.639	.407	.069	.076	.407	2.958
1990	2.362	1.231	.651	.113	.108	.713	5.178
2000	3.145	1.773	.833	.144	.138	.963	6.995
2010	4.018	2.337	1.120	.156	.155	1.242	9.028
2020	5.169	3.042	1.379	.191	.191	1.595	11.567
2030	5.651	3.462	1.689	.234	.234	1.802	13.092

CORPS OF ENGINEERS	**** METROPOLITAN WASHINGTON AREA ****	WATER RESOURCES ENGINEERS
DEPARTMENT OF THE ARMY	**** WATER SUPPLY STUDY ****	A DIVISION OF CAMP DRESSER AND MCKEE
BALTIMORE DISTRICT	**** WATER DEMAND PROJECTION MODEL ****	SPRINGFIELD, VIRGINIA

TABLE I-9

FAIRFAX CITY DEMAND AREA - MONTHLY
DEMANDS BY TIME HORIZON

TIME HORIZON	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1976	6.741	6.741	6.773	7.343	7.791	8.346	8.933	8.521	8.172	7.458	7.201	7.166
1980	9.463	9.463	9.506	10.308	11.046	11.928	12.862	12.206	11.651	10.516	10.109	9.976
1990	13.407	13.407	13.471	14.603	15.778	17.130	18.559	17.555	16.704	14.966	14.322	14.134
2000	16.524	16.524	16.602	17.998	19.525	21.252	23.078	21.795	20.708	18.467	17.652	17.420
2010	20.652	20.652	20.750	22.495	24.507	26.740	29.102	27.443	26.038	23.165	22.062	21.771
2020	26.033	26.033	26.157	28.556	31.001	33.894	36.952	34.804	32.983	29.264	27.810	27.444
2030	32.072	32.072	32.223	34.933	38.411	41.961	45.821	43.109	40.812	36.119	34.261	33.809

TABLE I-10

LOUDOUN COUNTY DEMAND AREA - MONTHLY DEMANDS BY TIME HORIZON

TIME HORIZON	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1976	1.454	1.454	1.461	1.584	1.699	1.820	1.948	1.858	1.782	1.626	1.554	1.533
1980	1.929	1.929	1.936	2.101	2.306	2.498	2.698	2.557	2.428	2.195	2.060	2.033
1990	5.885	5.885	5.913	6.410	7.226	7.915	8.642	8.132	7.699	6.815	6.286	6.204
2000	9.428	9.428	9.473	10.270	11.657	12.765	13.978	13.140	12.430	10.980	10.072	9.939
2010	14.832	14.832	14.902	16.155	18.410	20.206	22.109	20.774	19.642	17.330	15.845	15.636
2020	21.743	21.743	21.846	23.663	27.075	29.738	32.555	30.576	26.901	25.476	23.227	22.921
2030	31.367	31.367	31.515	34.165	39.152	43.025	47.121	44.244	41.807	36.826	33.508	33.066

TABLE I-11

PRINCE WILLIAM COUNTY DEMAND AREA -
MONTHLY DEMANDS BY TIME HORIZON

TIME HORIZON	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1976	6.145	6.145	6.172	6.694	7.100	7.606	8.141	7.765	7.447	6.796	6.565	6.478
1980	4.934	4.934	4.955	5.374	5.696	6.088	6.504	6.212	5.965	5.460	5.271	5.201
1990	7.495	7.495	7.527	8.164	8.727	9.420	10.153	9.638	9.202	8.311	8.007	7.901
2000	9.472	9.472	9.512	10.317	11.090	12.023	13.010	12.317	11.730	10.530	10.119	9.986
2010	12.132	12.132	12.182	13.214	14.273	15.532	16.862	15.927	15.136	13.517	12.960	12.789
2020	15.137	15.137	15.198	16.487	17.881	19.514	21.241	20.028	19.000	16.900	16.170	15.957
2030	18.698	18.698	18.773	20.366	22.158	24.246	26.454	24.903	23.589	20.904	19.974	19.711

TABLE I-12

CHARLES COUNTY DEMAND AREA - MONTHLY DEMANDS BY TIME HORIZON

TIME HORIZON	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1976	1.531	1.532	1.535	1.610	1.726	1.872	1.948	1.871	1.869	1.659	1.593	1.562
1980	2.649	2.651	2.655	2.765	3.025	3.306	3.450	3.303	3.300	2.897	2.756	2.702
1990	4.605	4.610	4.617	4.842	5.298	5.832	6.107	5.826	5.821	5.053	4.791	4.697
2000	6.202	6.208	6.217	6.520	7.159	7.907	8.293	7.899	7.892	6.816	6.452	6.326
2010	7.980	7.988	8.060	8.390	9.245	10.237	10.749	10.227	10.218	8.790	8.302	8.140
2020	10.220	10.230	10.244	10.745	11.867	13.172	13.845	13.159	13.147	11.269	10.631	10.424
2030	11.519	11.530	11.547	12.111	13.421	14.920	15.692	14.904	14.890	12.736	11.964	11.749

TABLE I-13

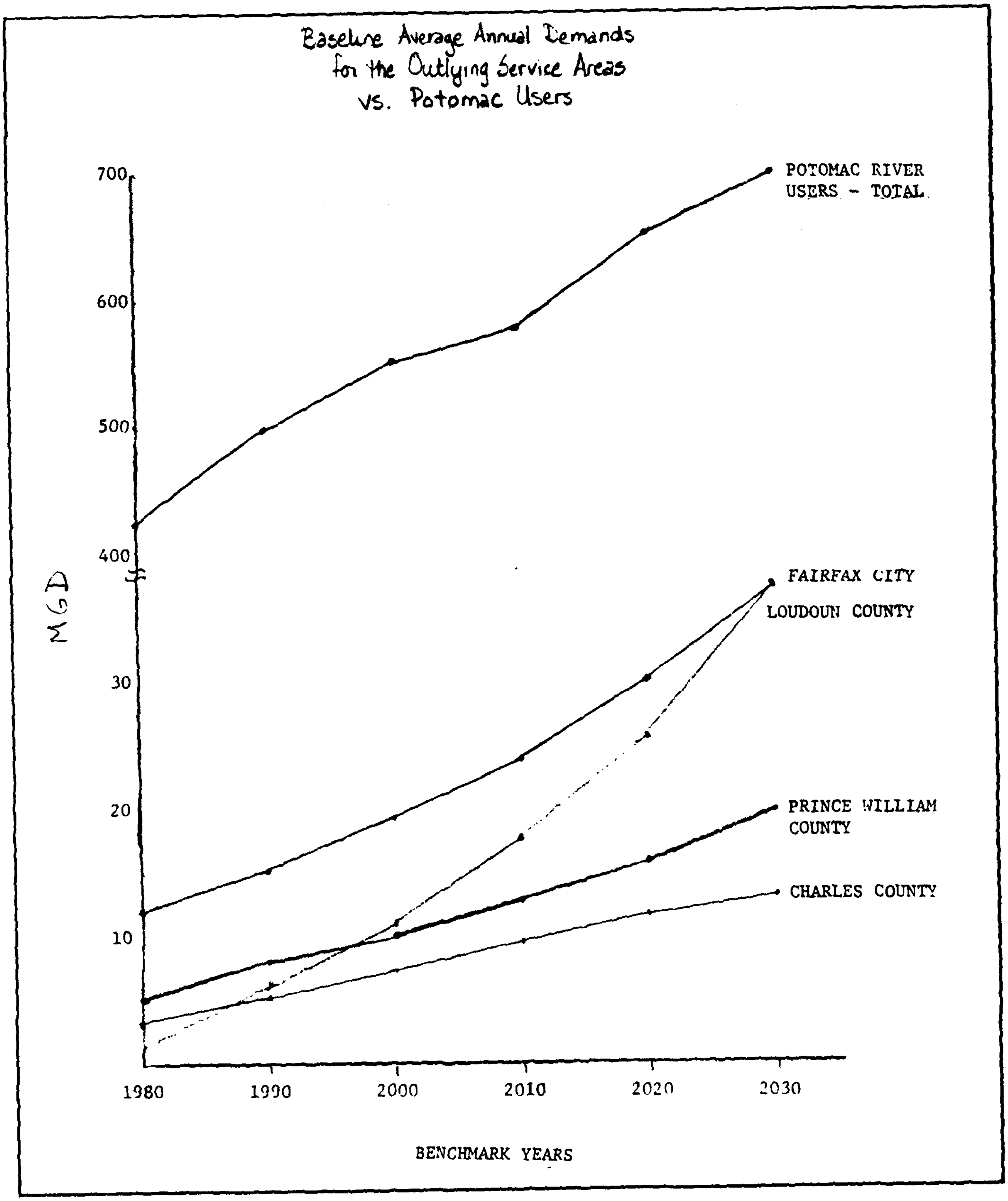
AVERAGE ANNUAL BASELINE DEMAND SUMMARY*

	1980	1990	2000	2010	2020	2030
Fairfax City, VA	10.8	15.4	19.0	23.8	30.1	37.2
Loudoun Co., VA	2.2	6.9	11.1	17.6	25.8	37.3
Prince William Co., VA	5.2	7.9	10.0	12.8	16.0	19.7
Charles Co., MD.	3.0	5.2	7.0	9.0	11.6	13.1

* In million gallons per day (MGD) without conservation

Based on MWCOG Round II population forecasts, 1980 census, water use and socio-economic data developed by the COE.

FIGURE I-4



Baseline Average Annual Demands
for the Outlying Service Areas
vs. Potomac Users
700
600
500
400
30
20
10
MGD
POTOMAC RIVER
USERS - TOTAL
FAIRFAX CITY
LOUDOUN COUNTY
PRINCE WILLIAM
COUNTY
CHARLES COUNTY
1980
1990
2000
2010
2020
2030
BENCHMARK YEARS

DESCRIPTION OF THE EXISTING WATER SERVICE AREAS AND WATER SUPPLY FACILITIES

FAIRFAX CITY SERVICE AREA

The Fairfax City Service Area is comprised of three major areas in northern Virginia to include the City of Fairfax and Town of Herndon in Fairfax County, and the Loudoun County Sanitation Authority (LCSA) in Loudoun County (Figure I-1). These areas derive their entire water supply from the Goose Creek and Beaverdam Creek reservoir system. The City of Fairfax Department of Water and Sewer Service is the governmental agency responsible for the withdrawal, treatment, and transmission of finished water to customers within the Fairfax City Service Area. It provides water on a retail basis to the City of Fairfax and on a wholesale basis to the LCSA and the Town of Herndon. The organizational structure of the Fairfax City Service Area is presented in Figure I-5.

The most intensively developed area within the Fairfax City Service Area is the City of Fairfax which, by 1975 was almost 80 percent developed, primarily with residential units. The Town of Herndon is relatively less developed than Fairfax City; however, the major access routes which pass through this area (Route 28 and Route 7) and link it to Washington D.C. will likely contribute to its intensive development in the future. Loudoun County's growth management policies are directed toward maintaining a balance between growth and the environment. These policies favor planned growth in areas such as Sterling Park, Sugarland Run, and other small cluster developments which are primarily in the eastern sector of the county. The LCSA portion of the service area encompasses many of these areas of projected growth and is therefore also expected to develop rather intensively in the future.

WATER SUPPLY SOURCES

As noted earlier, the sources of supply for the Fairfax City Service Area are storage impoundments on Goose Creek and Beaverdam Creek (Figure I-6).

The Goose Creek reservoir is located on Goose Creek approximately 3.5 miles upstream of its confluence with the Potomac River. This project, designated solely for water supply use, is the smaller of the two reservoirs and has been in operation since 1960. The dam itself is a concrete weir which operates as a run-of-the-river structure and serves only to impound water for pumped withdrawal. A fish ladder is provided up the right abutment facing downstream. In addition to normal dam overflow, 2.5 to 5 cubic feet per second (cfs) may be lost through the fish ladder. Other than pumped withdrawal, no other outlet works are provided.

The Goose Creek Reservoir when initially constructed had a total storage capacity of approximately 330 million gallons (mg) of water; however, due to the accumulation of sediment, the original storage capacity has been reduced. As presently operated at its normal conservation pool elevation of 240 feet mean sea level (msl), the reservoir has an estimated total storage capacity of 200 MG of water. This later value has been used for available water supply. At the normal conservation pool elevation the water surface area created is 65 acres.

FIGURE I-5
Organizational Structure Of The Fairfax City Water Service Area

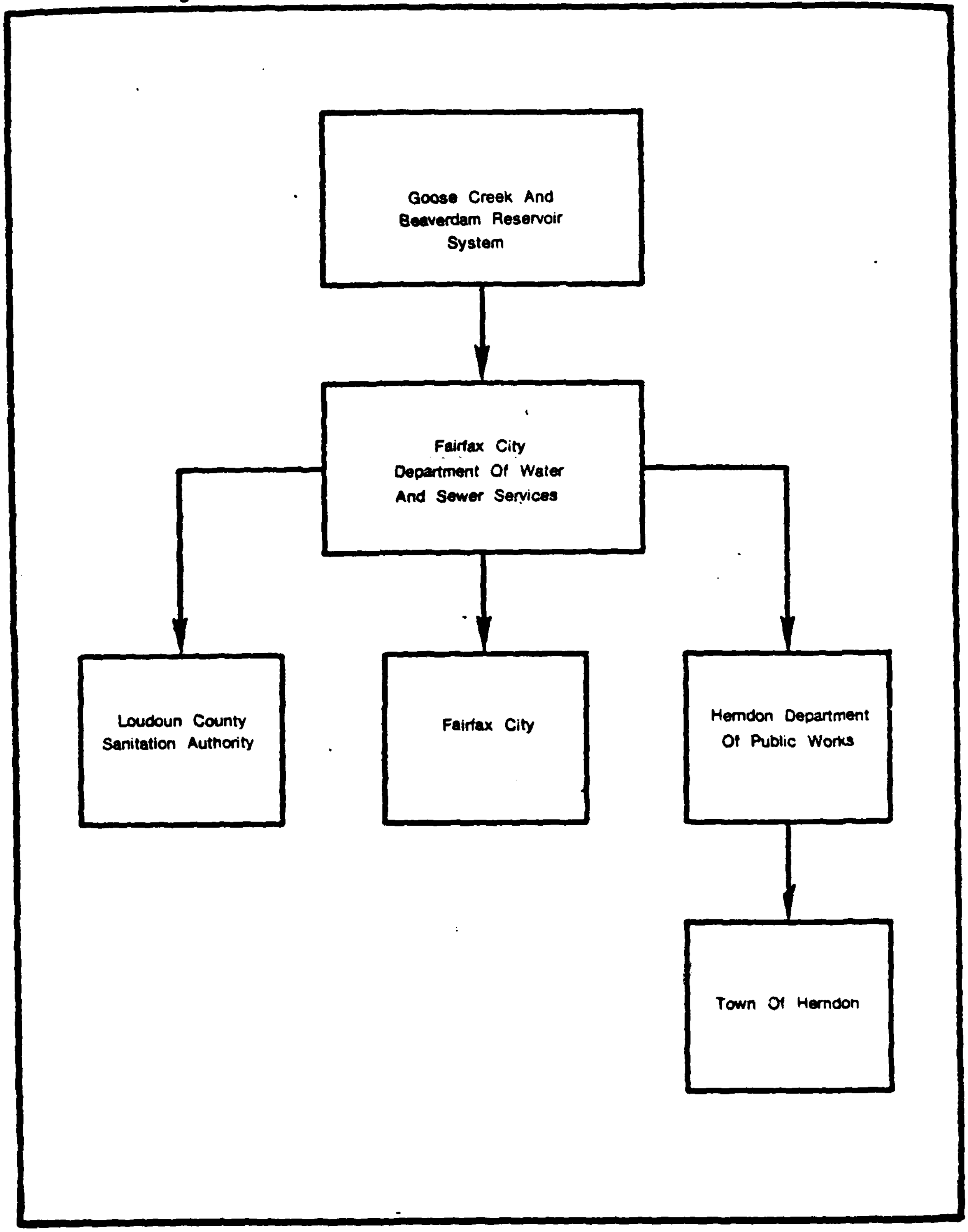
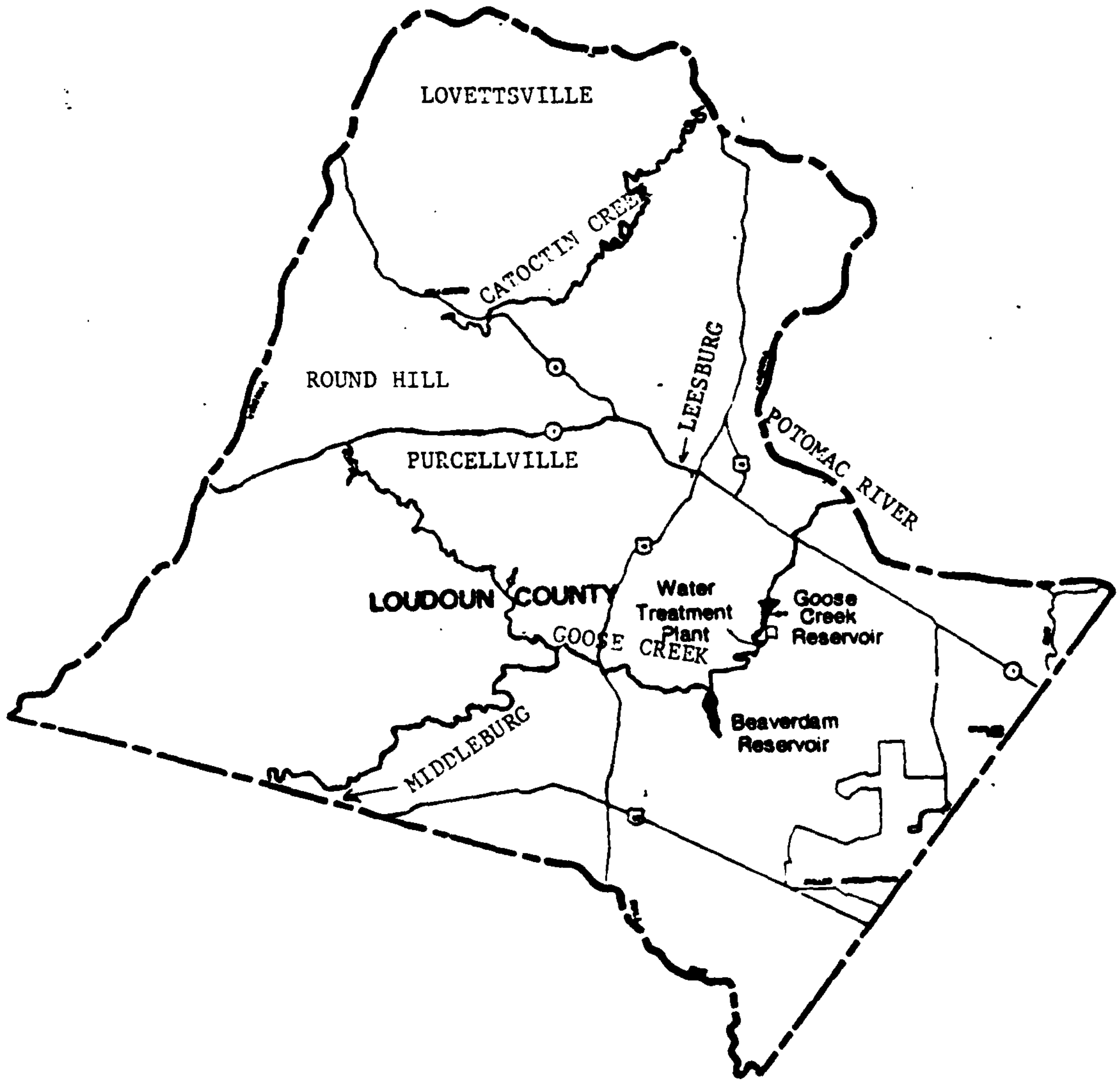


FIGURE I-6

WATER SUPPLY FACILITIES - FAIRFAX CITY SERVICE AREA



The safe yield for the Goose Creek impoundment is 2.84 million gallons per day (mgd), given the discharge over the top of the dam only. This value for the safe yield was developed by the Consultant Engineering firm of GKY & Associates, Springfield, Virginia for the MWA Water Supply Study. A filled-in-gage record for Goose Creek near Leesburg, VA, (U.S.G.S. stream gage 01644000) was adjusted to the existing Goose Creek drainage area.

Goose Creek is an uncontrolled stream and its flows are quite variable over the course of any given year. Average annual flows based on the Leesburg, Virginia, gage are about 195 mgd; however, flows have dipped as low as 1.5 mgd during the summer months of 1930. Because of this flow variability, the Beaverdam Creek reservoir was constructed which allows for a smoothing out of natural low flows in Goose Creek. It is important to note however, that owing to its small drainage area about one to two years of average rainfall would be required to fill Beaverdam Creek Reservoir if it were depleted during a drought period.

The Beaverdam Reservoir and Dam is located on a small tributary to Goose Creek called Beaverdam Creek, approximately 3.7 miles upstream from the Goose Creek Dam. The project was constructed in the late 1960's and is intended for use as an emergency water supply source in the event of a drought. The Beaverdam Reservoir has a total storage capacity at its normal conservation pool level (290 feet msl) of 1450 mg of water with 1340 mg allocated for water supply. There is an additional 870 mg of storage space available at the site to provide for incidental flood control and about 760 mg for sediment storage. The spillway of the project was designed to allow for the addition of gates as a means to increase the present storage capacity. Expansion of the reservoir capacity for 500,000 gallons is planned for 1983-1984. The water surface area created at the normal conservation pool area is approximately 290 acres. The reservoir controls a drainage-area of 6 square miles. The safe yield for the Beaverdam Reservoir is 2.26 mgd based on operating the reservoir separately from Goose Creek and assuming the full working storage is accessable for withdrawal. Since this project is intended for emergency use only, the safe yield could exceed the 2.26 mgd given above; however, the drawdown must not exceed 6 inches per day in order to maintain the structural integrity of the embankments. Since the reservoir was filled in 1975, no releases have been made for water supply or other purposes; however, normal overflow has occurred. Table I-14 summarizes the physical characteristics of both projects.

TREATMENT AND DISTRIBUTION

Raw water from Goose Creek Reservoir is withdrawn through a 24 inch diameter intake located on the eastern shore of the reservoir, approximately 2000 feet upstream from the dam. The water is then pumped 2000 feet to the Goose Creek Water Treatment Plant through a 24 inch diameter conduit. The pumping station houses four pumps; three with a nominal capacity of 4.0 mgd each and one with a nominal capacity of 1.5 mgd.

The Goose Creek Water Treatment Plant, constructed in 1961, includes the following treatment processes: turbidity removal; iron and manganese reduction; and disinfection. The plant was originally operated at 7.5 mgd capacity for 30 day and 9.5 mgd for maximum one day capacity. Due to the increased demands placed on the system, the plant has been recently expanded from 9.5 mgd to 18.0 mgd with a peak

TABLE I-14

WATER SUPPLY CHARACTERISTICS - GOOSE CREEK RESERVOIR SYSTEM

Particular	Goose Creek Reservoir	Beaverdam Creek Reservoir
Type	Concrete Weir	Controlled Earthfill
Top of Dam (feet msl)	252	298
Height of Dam (feet)	27	50
Length of dam (feet)	715	1600
Spillway Crest Elevation (feet msl)	240	290
Spillway Length (feet)	500	175
Drainage Area (square miles)	358	6
Water Supply Storage (mg)	200	1340
Flood Control Storage (mg)	190	870
Surface Area at Conservation Pool (acres)	65	290
Safe Yield (mgd)	2.84	2.26

capacity of 27.0 mgd. There are presently two storage facilities located at the plant, a reinforced-concrete ground level clearwell with a capacity of 1,000,000 gallons and an elevated wash water tank with a capacity of 100,000 gallons.

Finished water from the treatment plant is pumped by three high-service pumps through a transmission main consisting of 79,500 feet of 24-inch pipe and 35,000 feet of 16-inch pipe to the City of Fairfax. The transmission line terminates at a 900,000 gallon standpipe located on the west side of Fairfax City. Finished water sold to the Loudoun County Sanitation Authority, Town of Herndon, and Fairfax County Water Authority is metered at several connection points along the 24 inch transmission main. Figure I-6 is a location plan of the water supply sources, transmission and storage facilities, and the wholesale customer withdrawal points. Finished water storage with the service area consists of: (a) 900,000 gallons and 4 mg tank in the City of Fairfax and (b) a 1 mg tank located in Sterling Park, Loudoun County and a 300,000 gallon tank in the Town of Herndon.

LOUDOUN COUNTY SERVICE AREA

Loudoun County is one of the northernmost counties in the Commonwealth of Virginia. It is located approximately 30 miles west of Washington, D.C., and borders the Potomac River on the north and west (Figure I-1). The county is approximately 517 square miles in size, 95 percent of which drains directly to the Potomac River. The remaining five percent drains to the Occoquan Creek watershed in Prince William County and then to the Potomac River, at the border between Fairfax and Prince William Counties.

The eastern portion of the county which is closest to the Washington, D.C. urban core is part of the LCSA portion of the Fairfax City Service Area discussed in the previous section. Discussions with County planning officials indicate that the eastern sector is where planners would like to direct most future growth. There are several factors which contribute to this thinking such as accessibility to the urban MWA, availability of sewage disposal through the Potomac interceptor, the availability of public water supply from

the City of Fairfax Goose Creek system, location of Dulles International Airport, and the County's positive experience in Sterling Park (a new residential area) to attract home buyers to the area. The future growth is expected along both sides of Route 7 in the form of new large scale communities and industrial centers. Limited growth can also be expected along Route 15.

The Loudoun County service area as defined for this report consists of the remainder of the County, primarily the western and southern sectors which are less suburban and more rural in character than the eastern section. In the western section of the county, several water supply systems exist, each of which serve a small area or an incorporated town. In the areas with no publically owned water supply systems, the residents manage their own private water supply sources which, in most cases, are wells. The major public supplies include the towns of Leesburg, Hamilton, Purcellville, Round Hill, Middleburg, Lovettsville, and Hillboro, Lucketts, Aldie, and others as shown in Figure I-7. With the exception of Leesburg, all are located in the western section of the County. The following sections provide a description of the water supply facilities of the Town of Leesburg, which represents the largest supplier in the service area, as well as the other communities which are scattered throughout the County.

TOWN OF LEESBURG

The water supply system for the Town of Leesburg is comprised of eight wells, a 90,000 gallon ground storage reservoir, two 1.5 mg gravity storage tanks, and a booster pump station. In the fall of 1982, a new Potomac River intake and water treatment plant will become operational and will be capable of providing a maximum flow of 10 mgd. The location of the new facilities is shown in Figure I-8. The construction of these facilities was undertaken to replace the existing well supplies with a more dependable source since the observed yields of the existing well system cannot be guaranteed. This additional source will also enable the Town to expand its developmental capability beyond that which it can currently support through its existing water supply system.

Table I-15 provides a summary of the well characteristics in the Leesburg system based on test data collected by the Commonwealth of Virginia. Water from most of the wells is chlorinated and fluoridated before it enters the Town's distribution system.

TOWN OF HAMILTON

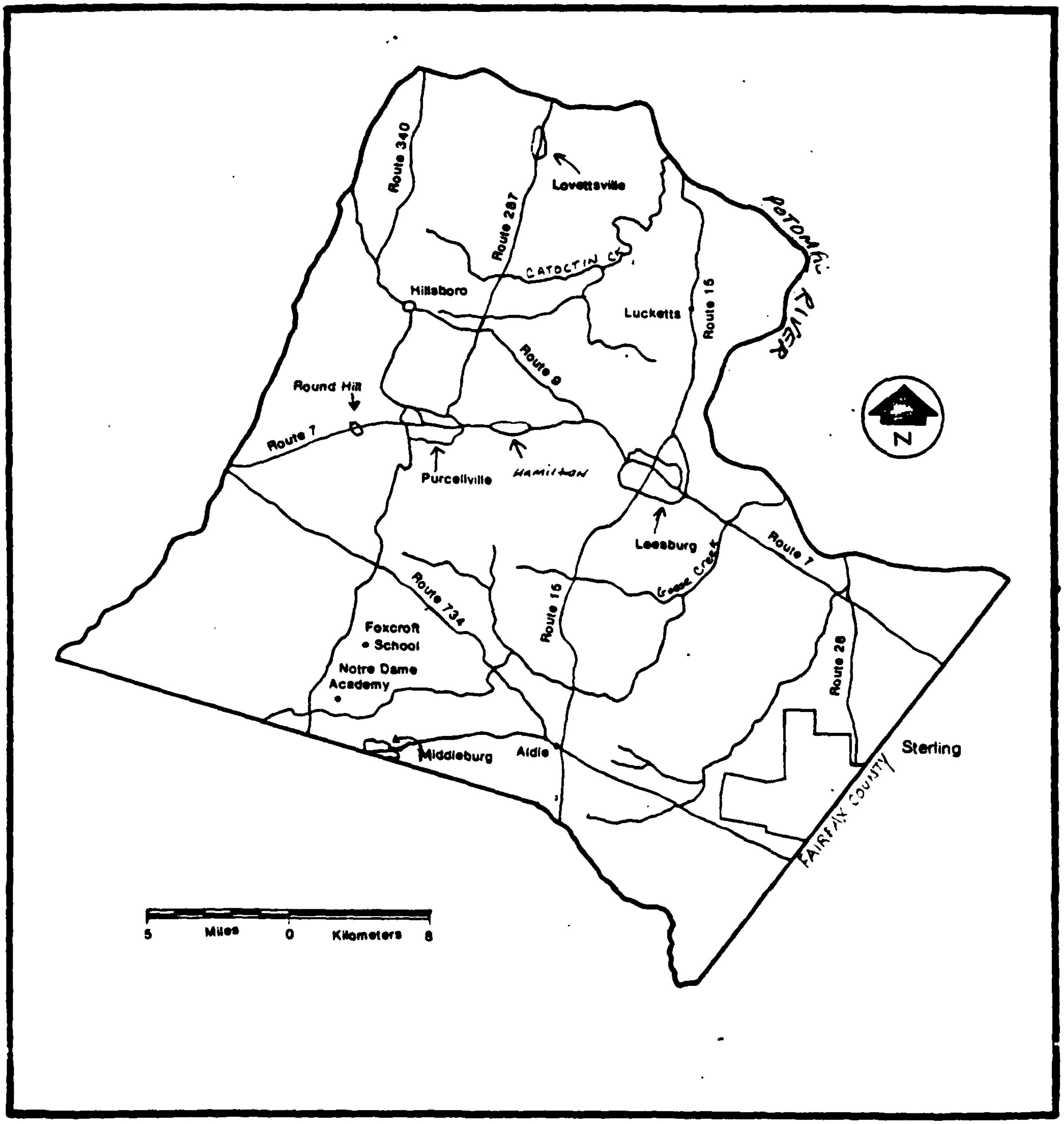
This area includes the Hamilton Acres subdivision and the Town of Hamilton. The systems are comprised of nine wells, a 500,000 gallon ground storage tank, a 60,000 gallon elevated storage tank and two 200 gallon per minute (gpm) rated booster pumps. Water treatment for the system includes chlorination and fluoridation for all wells. Turbidity removal is included at one of the wells. Table I-16 summarizes the well data for the system. In 1976, the Town's water supply system was limited to 416 residential connections based on source limitations.

TOWN OF PURCELLVILLE

The Town of Purcellville obtains its raw water supplies from three groups of springs known as the Harris Springs, Potts Springs, and Cooper Springs. Water from each group flows overland into an open earthen impoundment with a concrete dam. The three impoundments (known collectively as the J. T. Hirst Reservoir) are almost identical and

FIGURE I-7

WATER SUPPLY SYSTEMS IN WESTERN LOUDOUN COUNTY



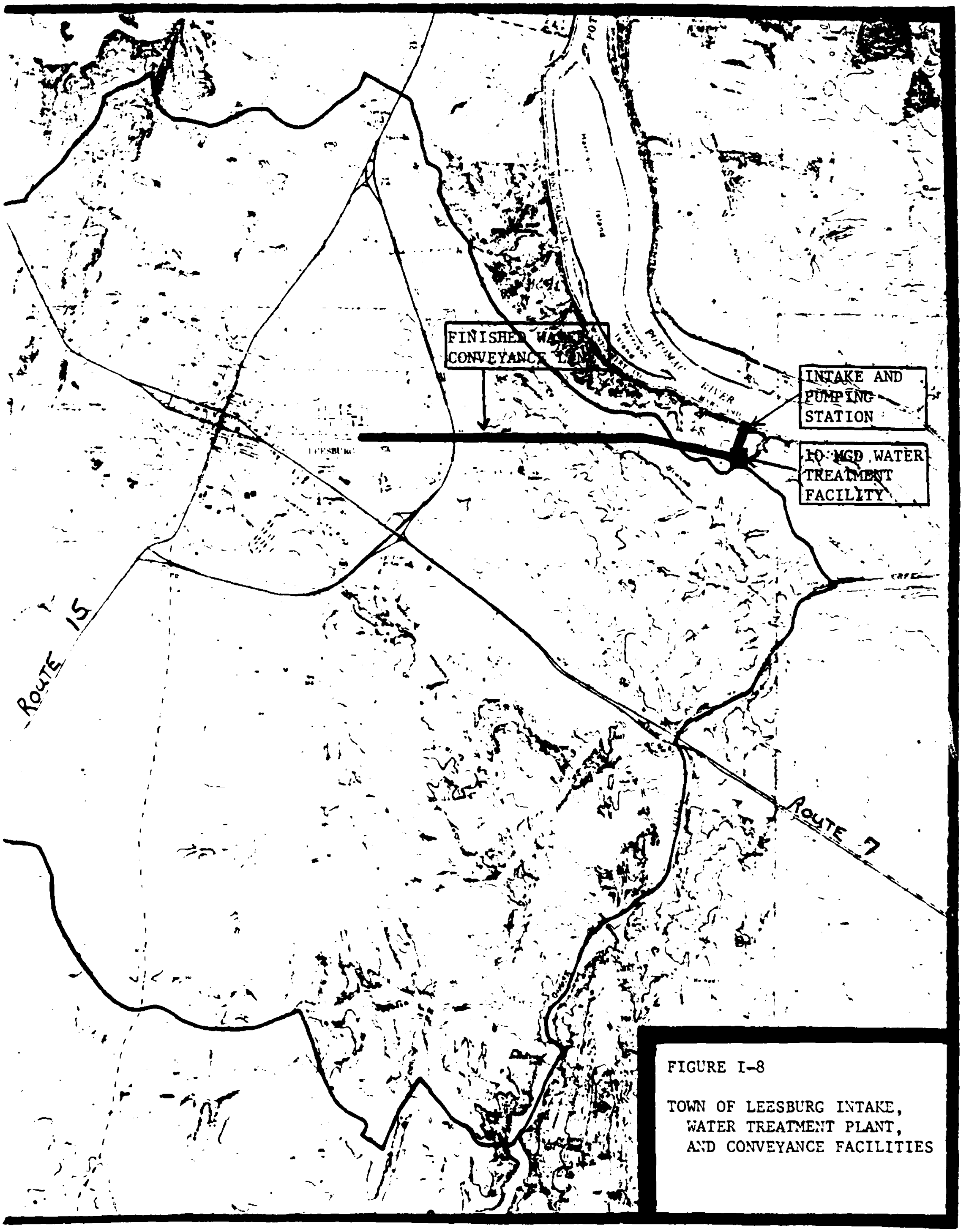


FIGURE I-8

TOWN OF LEESBURG INTAKE,
WATER TREATMENT PLANT,
AND CONVEYANCE FACILITIES

TABLE I-15

LEESBURG WATER SUPPLY - WELL DATA

Well Number	Location	Depth Ft.	Pump HP	Pump Capacity GPM	Yield Test Duration of Test (hrs)	Yield Test Yield GPM
1	Royal & Liberty Sts.	360	5	40	N/A	N/A
2	Royal Street	150	10	60	N/A	N/A
3	Near Town Firehouse	349	N/A	150	N/A	N/A
4	North & Wildman Sts.	400	50	500	24	480
5	Washington St.	328	40	470	48	450
6	Route 7 Leesburg By-Pass	350	50	375	8	250
7	Evergreen Road	145	30	350	48	325
8	Evergreen Road	115	30	500	48	500

Source: Commonwealth of Virginia, Department of Health, Water Works Operation Permit Number 6107300 dated 10 September 1979.

TABLE I-16

TOWN OF HAMILTON WATER SUPPLY SYSTEM -
WELL DATA

Well Number	Location	Depth Ft.	Pump HP	Capacity GPM	Yield Test Duration (hrs)	Yield Test Yield GPM	Remarks
	Hamilton Acres Subdivision						
1	Route 7	400	10	63	72	60	
2	Route 7	400	7-1/2	N/A	72	24	
	Town of Hamilton						
1	Route 7 & Route 710	210	3	N/A	24	24	Present yield is estimated at 11 GPM
2	Route 7 & Route 710	413	N/A	N/A	N/A	18	Present yield is estimated at 11 GPM
3	Route 710 & Route 709	260	3	N/A	48	8	
4	Route 710 & Route 709	725	3	N/A	48	25	
5	Route 710 & Route 7	267	5	N/A	77	29.1	Present yield is estimated at 17 GPM
6	Hamilton Knolls	307	5	N/A	24	80	Present yield is estimated at 26 GPM
7	Applewood Court	230	10	N/A	48	55	
8	Route 709 & Route 7	386	3	N/A	24	42	Present yield is estimated at 16 GPM
9	Route 709 & Route 7	400	10	N/A	48	100	

Source: Commonwealth of Virginia, Department of Health, Water Works Operation Permit.

are approximately 20 feet wide by 50 feet long and 3 feet deep. Each of these impoundments contains a screened spillway. Water flows over the spillway and into a small screened basin containing an outflow pipe leading to the downstream water system facilities. The J. T. Hirst Reservoir has a total capacity of 39 mg. This reservoir and the springs are subject to surface contamination. Water samples by others have indicated that, at times, iron concentrations, color, and dissolved oxygen (DO) levels were unacceptable.

Water from Harris Springs Impoundment and the Potts Springs Impoundment flows via a 6-inch line to a 5-acre reservoir or to the Town, depending upon the head conditions. Water which overflows the Harris Springs Impoundment and the Potts Springs Impoundment flows overland to a 3-acre reservoir which also collects surface water runoff from the above drainage area. Water from the 3-acre reservoir overflows into a small settling basin from which water may be diverted to the 5-acre reservoir or to an adjacent stream by means of a manually operated gate. Water from the Cooper Springs Impoundment is conveyed to the Town in a separate line.

Unfortunately, very few records of flow from the springs are available. Four months of flow measurements (June through September 1976) taken by others showed the total flow of all three springs to range from 0.08 mgd to 0.49 mgd with an average of 0.23 mgd. It is difficult to assign any probability to such a small data sample. It would require data for several years to calculate any statistical significance. In July 1977, the largest of the three springs, Cooper, was essentially dry. However, this was considered to be very unusual and might have been the first such occurrence since the spring was tapped in 1930. According to newspaper accounts, the Purcellville Springs yielded 0.1 mgd in 1930 - the worst drought on record.

The Town has a usable storage capacity of one mg in an uncovered steel ground storage tank located on the southside of Short Hill Mountain. Water is conveyed by gravity from the storage tank to the town's distribution system. Another 60,000 gallon elevated storage tank located within Purcellville is not presently used because its elevation is below the hydraulic gradient. Treatment consists of chlorination and pH adjustment by line feeding from treatment units housed in a station about 4000 feet below the J. T. Hirst Reservoir.

The Town's distribution system has been a problem for quite some time. Part of the problem is that the water exhibits low pH, low hardness, and low alkalinity all of which have led to extensive corrosion in the small, unlined mains. Many of the smaller mains are dead-ended and do not allow for proper circulation of water. This permits sediment to settle out in the mains. As of April 1977 there were 651 connections to the town's water system.

TOWN OF ROUND HILL

Initially, the Town of Round Hill's water supply system consisted of three springs located northwest of the Town on the eastern slope of the Blue Ridge Mountains. One of the springs, however, was condemned by the Virginia Department of Health due to presence of contaminated surface runoff. Presently, two of the springs furnish all of the water to satisfy the town's needs. Since these springs cease to flow during the dry periods, a 10 mg unlined reservoir, with a maximum depth of 19 feet, was constructed in the late 1950's to store and furnish water during dry spells. This reservoir has three outlet pipes

1950's to store and furnish water during dry spells. This reservoir has three outlet pipes at depths of 6, 15, and 19 feet. Two stone catch basins, one at each of the springs, serve to collect water. A 4-inch cast iron pipe conveys water by gravity from catch basins to either the 10 mg reservoir or to another 0.2 mg finished water reservoir, depending on the valve arrangement. However, normal routing of the water is to the 0.2 mg reservoir. No system yield has been determined since flows from the springs have not been measured.

The raw water receives chlorination prior to entering the 0.2 mg finished water reservoir. As of February 1975, there were 254 connections to the town's water system and the present number is estimated to be still below 260.

TOWN OF HILLSBORO

The water supply system of the Town of Hillsboro consists of a spring and distribution system. The Town obtains its water from a spring which is located off Route 9 and is enclosed in a stone building with a wooden roof. Inside the building is an oval rock basin with an approximate capacity of 500 gallons. Spring water enters the basin through cracks in the rock bottom and exits through either a screened outlet pipe to the Town or an overflow pipe discharging into a pit outside of the building. There is no development above the spring. The elevation difference between the spring and the homes served by this system is sufficient to provide gravity flow and operating pressure throughout the Town. There is no storage capacity other than 500 gallons capacity provided by the basin.

Water from the spring is supplied directly to the consumers without treatment in a 1/2 mile cast iron pipe. As there is no information on the yield of the spring, the Virginia Department of Health has set an upper limit of 30 connections.

TOWN OF LOVETTSVILLE

The water supply system for the Town of Lovettsville consists of two wells equipped with iron and manganese removal treatment and a 7500 gallon elevated steel storage tank. Table I-17 summarizes test yield data developed by the Commonwealth of Virginia in 1977. A six inch water main conveys treated water throughout the Town. As of 1977, there were 130 residential and business connections in the Town with an additional 119 committed.

TOWN OF MIDDLEBURG

This system consists of two wells, a 60,000 gallon elevated storage tank and a small distribution system consisting of a 6 inch transmission main. Well Number 1 is 772 feet deep and is designed to deliver approximately 70 gpm. No yield data was available for this well. Well Number 2 yielded 150 gpm based on a 24-hour test. Based on the limited storage capacity, the Town is limited to 300 residential connections.

OTHER SMALL COMMUNITIES

In addition to these Communities, there are several water supply systems which serve individual developments/institutions or a small group of houses. These are listed in Table I-18.

TABLE I-17

TOWN OF LOVETTSVILLE - WELL DATA

Well Number	Location	Depth Ft.	Pump HP	Pump Capacity (GPM)	Yield Test Duration Hrs.	Yield Test Yield GPM
1	Route 855 & Route 287	500	7.5	40	72	40.5
2	Lake View Village Development	200	15	N/A	72	131

SOURCE: Commonwealth of Virginia, Department of Health Permit No. 6107400 dated 24 June 1977.

TABLE I-18

SMALL LOUDOUN COUNTY SYSTEMS

Notre Dame Academy - 4 wells, 1200 gallon storage
Lucketts Mobile Home Park - one well, 320 gallon tank
Village of Aldie - Spring, 7000 gallon storage
Highway Trailer Court - one well, 30 gallon storage
Fox Croft School - 4 wells, 100,000 gallon tank
National Children's Rehabilitation Center - 2 wells, 1500 gallon storage
Glaydin School - 2 wells, 800 gallon storage
Margaret Paxton Home for Children - one well, 1000 gallon tank
Potomac Farms - one well, 5000 gallon tank
Others - Private homes with private wells.

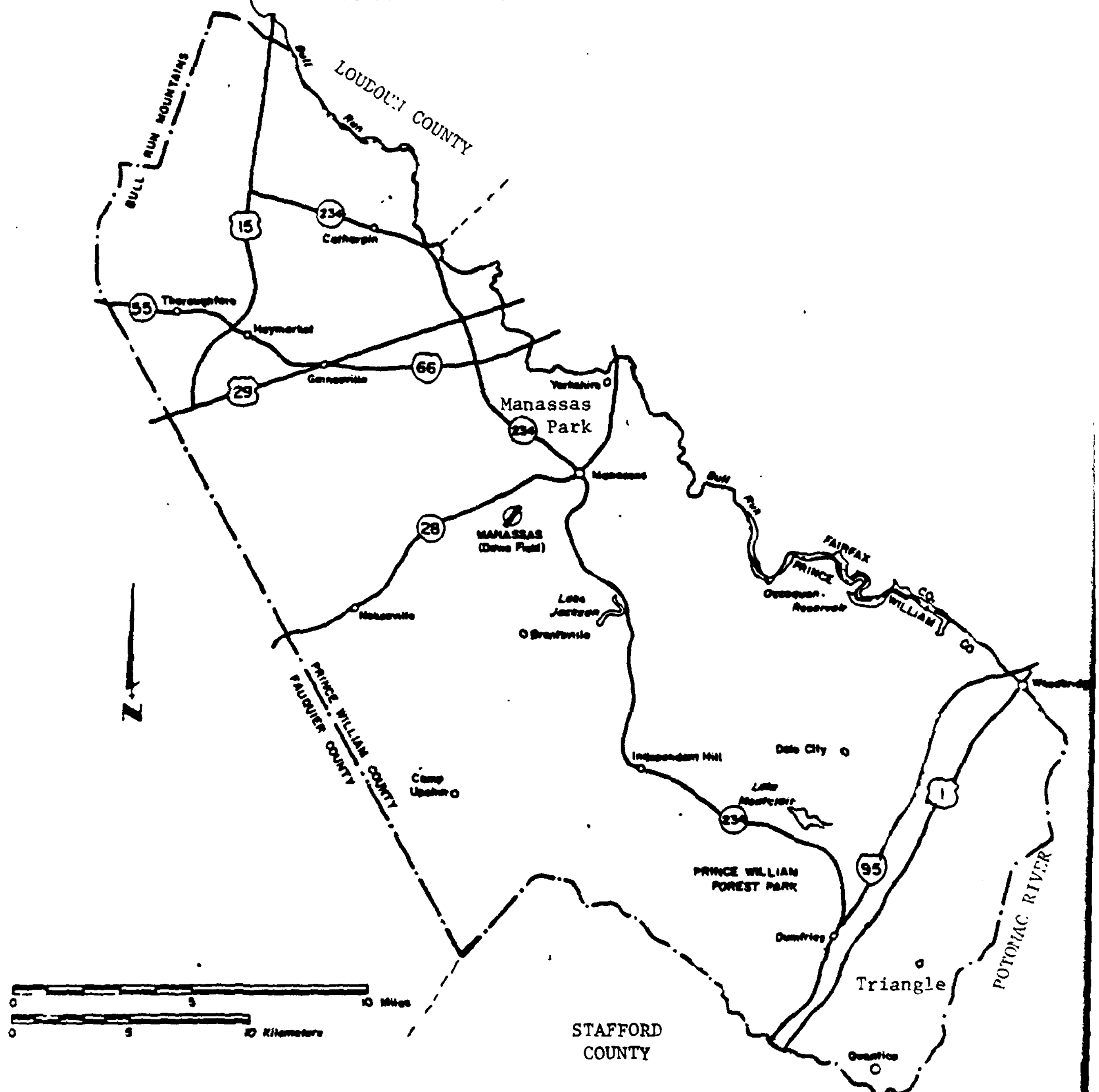
PRINCE WILLIAM COUNTY SERVICE AREA

Prince William County, Virginia lies approximately 20 miles southwest of Washington, D.C., and is bounded by the Potomac River on the southeast, Fairfax and Loudoun Counties, Virginia, to the northeast, and Fauquier and Stafford Counties, Virginia, to the south and west (Figure I-1).

Prince William County is one of the smaller counties in the Metropolitan Washington Area with a total county area of 340 square miles. The major cities are: Dale City, Dumfries, Manassas, Manassas Park, Occoquan, Triangle and Woodbridge (Figure I-9). The county is both rural and urban in character. Within the past 20 years land use has become increasingly urbanized which has contributed to the county's water supply problems. The development has largely occurred along the major Interstate Routes, I-66 and I-95. The major cities along the Interstates have been affected by most of the development. Also low density residential development has encroached upon agricultural areas. In turn, agricultural areas are diminishing and being replaced by rural subdivisions such as those in the upper Powells Creek region. The southeastern and northern portions of the county have mostly been affected by these changes in land use. The U.S. Marine Corps also has a training facility within the county. The facility, known as Quantico Marine Base, occupies the southeast portion of the county.

FIGURE I-9

VICINITY MAP - PRINCE WILLIAM COUNTY



Prince William County water supply is provided by several major sanitary districts as well as a number of small community systems. The sanitary districts can have a variety of functions which are outlined in state legislation. Examples of these functions are: water supply and related services, wastewater treatment, refuse collection, and power services. The community systems are more limited in their services. Generally they provide supply and distribution services that for a designated community or subdivision.

The major public purveyors of water within Prince William County include: the City of Manassas, the City of Manassas Park, the Greater Manassas Sanitary District (GMSD), the Occoquan-Woodbridge-Dumfries-Triangle Sanitary District (OWDTSD), and the Yorkshire Sanitary District (Figure I-10). Other sanitary districts which have recently been organized from existing private systems include the Oak Ridge Sanitary District and the Bull Run Sanitary District. Some of these water suppliers have permanent interconnections and many, emergency interconnections which allows them to share sources during critical periods. All of the smaller community systems however have developed their own supply systems and operate independently.

Two major areas which are located in Prince William County but were not phased as areas to be served by public systems for the Prince William County service area are the Town of Quantico and the OWDTSD. The Town of Quantico receives its supply from the U.S. Marine Corps Base at Quantico which has an ample supply base from separetely owned reservoirs. The OWDTSD is supplied directly by the Fairfax County Water Authority (FCWA). The development of plans for the FCWA are documented in Appendix B of this report. Should the OWDTSD desire to develop a base of supply independent from the FCWA, some of information developed in this Appendix might be useful for their further consideration.

CITY OF MANASSAS

The City of Manassas uses two major sources of supply, the Broad Run Impoundment and several groundwater wells. The Broad Run Impoundment, also referred to as Lake Manassas, is located in the northwestern sector of the county. Construction of the dam and reservoir was completed in 1972. The reservoir was intended to replace the City's well system as the principal source for that municipality. A drainage area of 60 square miles contributes to the reservoir. The dam itself is a combination concrete gravity dam and earthfill dam. Some of the salient physical characteristics of the project are summarized in Table I-19. The safe yield of the project given the current spillway crest of 285.0 feet m.s.l. was found to be 15.3 mgd based on computer model runs made by GKY Associates for the MWA Water Supply Study. Raising the normal pool level of Lake Manassas to elevation 290.0 feet msl, 295.0 feet msl and 300.0 feet msl by the addition of bascule gates or tainter gates has been discussed; however, no firm plans have been initiated to raise normal pool. The City of Manassas owns the shoreline up to elevation 300.0 feet msl at the present time.

The City of Manassas has six wells which are presently in use. Total pumpage based on information provided by Prince William County in 1980 was 0.7 mgd. The depth of wells range from 250 to 1000 feet. Geraghty and Miller, Inc., reported in 1978 that several wells in the Manassas area had experienced declines in water levels due to concentrated pumpage; however, the dimensions of the water level cone of depression were unknown as information was unavailable on the rate of water level decline.

Figure I-10 Organization Of Prince William County Water Suppliers

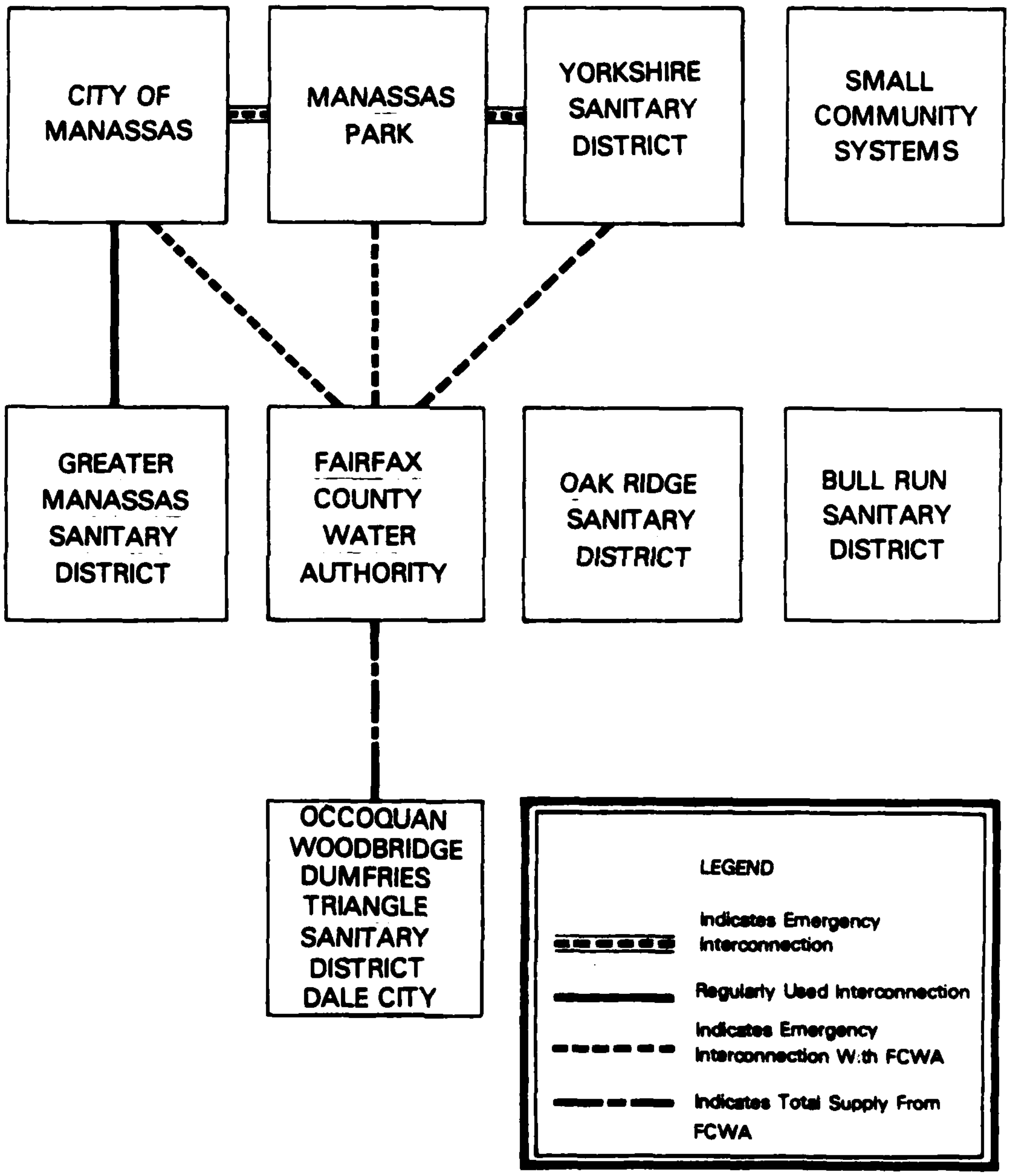


TABLE I-19

PHYSICAL CHARACTERISTICS OF BROAD RUN DAM AND RESERVOIR

Top of Dam	302.0 msl
Normal Conservation Pool	285.0 msl
Total Storage at Normal Pool Level	17,500 acre-ft
Usable Storage at Normal Pool Level	12,666 acre-ft
Flood Control Storage above Normal Conservation Pool Level	15,100 acre-ft
Buffer and Inactive Storage	4,834 acre-ft
Drainage Area to Reservoir	6(square miles
Surface Area at Normal Conservation Pool	7.5×10^2 acres
Safe Yield	15.3 MGD

Source: GKY & Associates, Alexandria, VA, Hydrologic and Hydraulic Data Report, July 1978

A 4.0 mgd capacity water treatment plant located *immediately downstream* of the Broad Run Impoundment provides coagulation, flocculation, sedimentation, filtration, disinfection, and fluoridation. One 2.5 mg ground storage tank and two elevated storage tanks of 0.3 mg and 0.075 mg provide storage and pressure for the distribution system. Water from the well system is untreated.

CITY OF MANASSAS PARK

The City of Manassas Park currently uses four wells which collectively furnish about 0.7 mgd and supply about 2000 connections. These wells range in depth from about 700 to 1000 feet. The City is interconnected with both the Yorkshire Sanitary District, the City of Manassas, and the FCWA where additional supply could be purchased in the event of any emergency. A 0.25 mg standpipe and a 0.925 mg tank provide finished water storage for the community.

GREATER MANASSAS SANITARY DISTRICT

The Greater Manassas Sanitary District (GMSD) obtains its water supply from a number of sources. These sources include nine drilled wells, and purchases from the City of Manassas, Yorkshire Sanitary District, and FCWA. State permits allow these districts to supply water to GMSD upon demand. The City of Manassas and Yorkshire Sanitary District provide water on a regular basis to the GMSD area. The City of Manassas, is obligated to supply a maximum of 0.3 mgd gallons per day upon demand. The GMSD may also purchase from FWCA, however, this is done infrequently.

The total capacity of the groundwater system is 2.07 mgd. Wells vary in depth from 300 to 900 feet. Four hydropneumatic tanks, a ground storage tank and an elevated storage tank feed and maintain pressures within the distribution system. The water from the well system is untreated and is discharged directly into the distribution system.

YORKSHIRE SANITARY DISTRICT

The Yorkshire Sanitary District relies on groundwater as its major supply source. It has emergency connections with both the Greater Manassas Sanitary District and the City of Manassas Park water systems.

The water system consists of three wells and an elevated storage tank. The total yield from these wells is estimated to be 1.12 mgd or to supply water to 1560 equivalent residential connections. Depth of wells range from 343 to 510 feet. The water receives no treatment before being released into the distribution system.

OTHER SMALL COMMUNITIES

Based on a review of public water suppliers by Water Resources Engineers in 1976 for the MWA Water Supply Study, a list of small community suppliers was developed for Prince William County. These systems are listed in Table I-20. All of these systems rely on groundwater as their sole water supply source. The total net contribution of these communities to the total service area is 0.77 mgd based on the available data.

CHARLES COUNTY SERVICE AREA

Charles County is located on the developing fringe of the MWA in southern Maryland. The County covers 457 square miles with the vast majority of land still open, being either agricultural, rivers and streams, or other open uses. In 1977, only 10 percent of the land area in the County was devoted to residential use. More recently open land has rapidly been developed along major traffic arteries; however, residential subdividions are also appearing in a sprawling pattern, particularly in the northern portion of the County. The communities of Waldorf, White Plains and LaPlata have expanded appreciably along the Route 301 corridor in recent years (Figure I-11). The St. Charles Community, which is a planned unit development, is also expected to bear high density development in future years. The eastern and southern areas of the County are expected to remain more rural in character with residential development being mostly limited to waterfront development, retirement homes and second homes.

Charles County is currently served by a combination of public, privately-owned community, and individual water supply systems. These systems obtain their water from groundwater. At the present time approximately 39 percent of the County is served by either a public or privately-owned community water system. The remaining 61 percent of the population is served by individual well systems that are scattered throughout rural portions of the County. The County anticipates that by the year 2000, an estimated 50 percent of the area will obtain its water supply from public systems. The existing water supply systems are generally decentralized. According to the Charles County Comprehensive Water and Sewer Plan it is anticipated that private water companies will be formed and dedicated to the Charles County Department of Public Works for operation and maintenance until central, regional and/or municipal systems are extended

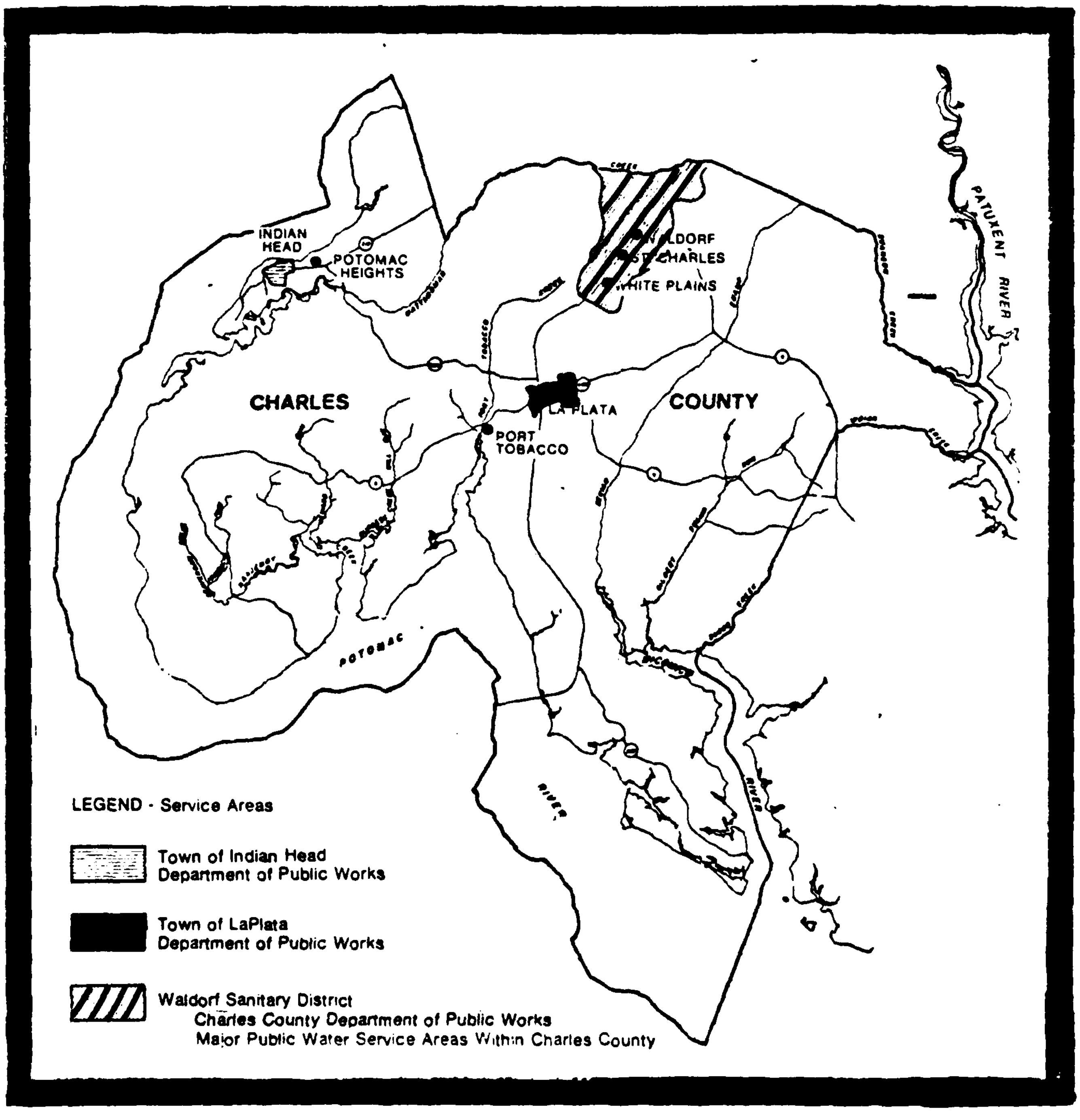
TABLE I-20

SMALL COMMUNITY WELL SYSTEMS -
PRINCE WILLIAM COUNTY

Community	Quantity Available (MGD)
Algonghin Hills Subdivision	0.05
Azalea Trailer Park	Negligible
Bull Run Mountain Estate	0.2
Elm Farm Trailer Park	Negligible
Evergreen Country Club	0.04
Field Unit #26	Not Available
Forest Park Trailer Park & Forest Grove Subdivision	0.1
Gainesville Mobile Home Park	Negligible
Gleaton's Trailer Acres	Negligible
GMSD - Gainesville Acres Well #16	0.01
Hillwood Mobile Home Park	0.01
Lakeview Estates	0.04
Lindon Hall School	0.06
Oak Ridge Estates	0.08
Occoquan Forest Subdivision	0.17
Prince William County School Board Complex	Not Available
Sommers Farm Subdivision	0.01
TOTAL	0.77

FIGURE I-11

MAJOR PUBLIC WATER SERVICE WITHIN CHARLES COUNTY



Major Public Water Service Areas Within Charles County

to supply adequate potable water services or new central systems are developed. As County services become available, the continued use of smaller private community systems will be discouraged and, eventually eliminated.

Currently, there are three public water supply systems within Charles County; the Charles County Department of Public Works, the Town of Indian Head Department of Public Works, and the Town of LaPlata Department of Public Works. Figure I-11 identifies the location of these service areas within the County. Figure I-12 is a schematic showing the organizational structure of each supply system. The following sections discuss the water supply facilities for each of these public systems.

CHARLES COUNTY DEPARTMENT OF PUBLIC WORKS (DPW)

The Charles County Department of Public Works (DPW) is a quasi-governmental agency that was created in 1976. This agency is responsible for the withdrawal, treatment, and distribution of groundwater to supply the communities of Waldorf, Spring Valley, Avon Crest, and Clifton-on-the-Potomac. The DPW also has the responsibility of operating and maintaining the collection and distribution system in each community.

Based on information provided by the DPW in December, 1980 it was determined that the water supply is taken from five production wells listed in Table I-21. All are deep well turbine pump systems which draw their water supply from the Magothy Aquifer (200-300 feet). The water is treated with chlorine and calgon to provide disinfection and iron particle control. One more well is programmed for addition to the public system. When the sixth well is placed on line, the Department will have the ability to produce a maximum of 4.0 mpply from the Magothy Aquifer (200-300 feet). The water is treated with chlorine and calgon to provide disinfection and iron particle control. One more well is programmed for addition to the public system. When the sixth well is placed on line, the Department will have the ability to produce a maximum of 4.0 mgd.

Table I-21

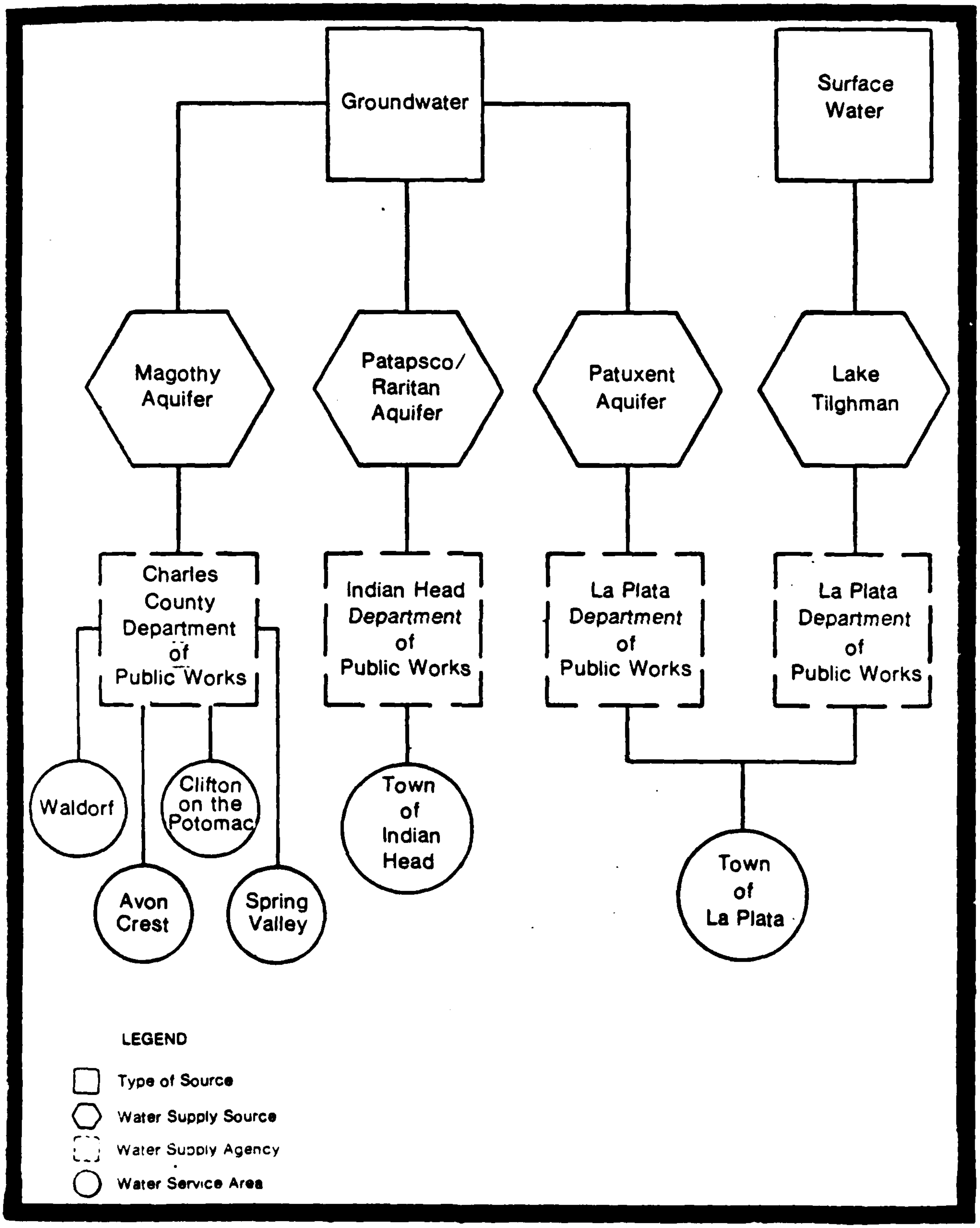
CHARLES COUNTY DEPARTMENT OF PUBLIC WORKS WELL SYSTEM

Source Name	Existing and Potential Yield MGD	Percent of Total (%)
North Well	0.42	15
South Well	0.27	10
Berry Well	0.69	25
Ryon Well	0.69	25
St. Charles Well	0.70	25
TOTAL	2.77	100

The Department of Public Works will be drilling at least three additional wells within the ten year period to provide for projected water needs in the Waldorf area. These wells will provide approximately 2.1 mgd of additional water and should meet the requirements for this area through 1990, based on their estimates. It is anticipated that these wells will be located on existing mains.

FIGURE I-12

ORGANIZATIONAL STRUCTURE OF MAJOR PUBLIC WATER SUPPLY SYSTEMS - CHARLES COUNTY



The Department of Public Works will be preparing a master plan for future water supply expansion, since demand for this essential quantity is increasing rapidly during the summer months as development continues. The Department of Public Works will be evaluating additional wells, elevated storage and surface storage wells for the next 10 year projection of this plan. A concern of the utility is the mining of the Magothy Aquifer which is dropping an estimated two feet/year. Consideration is being given to recharging the aquifer given this condition.

The water distribution system consists of a network of water mains varying in size from 6 to 16 inches in diameter. The storage system consists of three elevated storage tanks. The first tank is located on Route 925 behind the Waldorf Fire Department. This tank has a capacity of 200,000 gallons. The second tank is located on Smallwood Drive in St. Charles, and its capacity is 2,000,000 gallons. The last tank is located in Pinefield and its capacity is 1,000,000 gallons. The towers are all related by means of altitude valves, which allows for equal distribution of water throughout the distribution system.

TOWN OF INDIAN HEAD DEPARTMENT OF PUBLIC WORKS

Indian Head is one of two incorporated towns within Charles County. The Indian Head DPW is the agency responsible for the public water supply system that serves the users within the Town's corporate limits.

The Town's water supply is obtained from four productive wells which penetrate the Patapsco and Raritan Aquifers (Table I-22). Each well has a self contained treatment system consisting of pre-aeration, pre-chlorination, filtration, iron removal and disinfection.

Table I-22

INDIAN HEAD DEPARTMENT OF PUBLIC WORKS WELL SYSTEM

Well Number	Depth (feet)	Potential Yield (MGD)
1	250	0.54
2	275	0.13
3	290	0.29
4	Unavailable	0.15
Total		1.11

The finished water distribution system consists of a network of water mains ranging in size from 4 to 8 inches in diameter. A 250,000 gallon standpipe provides reserve storage and maintains operating pressure.

TOWN OF LAPLATA DEPARTMENT OF PUBLIC WORKS

LaPlata is the second incorporated Town in Charles County. The collection and distribution system for the Town is owned, operated, and maintained by the town of LaPlata DPW.

The Town's water supply is obtained in part from five productive wells that penetrate the Patuxent and Aquia Aquifers. Water from each well is treated separately for chlorination and ph-corrosion control. It is then discharged into the distribution system. A summary of the characteristics of these wells is summarized in Table I-23.

Table I-23

TOWN OF LAPLATA - WELL SYSTEM

Well Number	Depth (ft.)	Potential Yield MGD
5	800	0.26
6	800	0.12
7	800	0.07
8	900	0.72
9	800	0.04
Total		1.21

In addition to its groundwater supply, the Town has a surface water source that is used to augment supplies when necessary. The surface water supply source is Tilghman Lake, located just northeast of the Town on the U.S. Army Radio Receiving Station grounds. The impoundment was created by the excavation of material to provide the desired depth and side slopes for the lake bed and then the construction of an earth fill dam across a small tributary stream of the Kerrick and Zekiah Swamps. The dam is approximately 250 feet long and 15 feet high. The water surface elevation of the lake is controlled by an overflow structure located at the northern end of the dam. A drain pipe, located at the toe of the dam, allows valve-controlled discharge into an open natural channel. The total surface area of the lake is 5.4 acres with a storage capacity of 16 mg. Raw water withdrawn from this source is treated with potassium dichromate, lime and poly-electrolyte to improve the filterable qualities. It is then pumped through three rapid sand filters (each with a 100 gpm capacity). The filtered water is chlorinated (for disinfection) and fluoridated, and then discharged into a 100,000 gallon clear well reservoir. Two high-service pumps (200 feet total delivered head at 600 gpm) force the water through a 12 inch water main from the reservoir to the distribution system. The treatment plant has an initial capacity of 0.43 mgd with an ultimate capacity of about 0.86 mgd.

The finished water distribution system consists of a network of water mains ranging in size from one-quarter inch to 8 inches. The mains are composed of cast iron, galvanized iron, or asbestos-cement materials. They total approximately 13 miles. Finished water storage is provided by three elevated tanks with a combined capacity of 435,000 gallons.

OTHER COMMUNITY SYSTEMS

Within Charles County, there are fifty-one additional privately-owned and community water supply systems. These account for approximately 3.7 mgd of additional supply widely scattered throughout the County. According to the Charles County Water and Sewage Plan, the abundance of these small and independent systems is related to the lack of sufficient concentrated populations to finance a centralized public system. As noted earlier, it is expected that the expansion of municipal systems will be programmed to be compatible with regional development plans which favor centralization of public services.

REVIEW OF PLANNING STUDIES CONDUCTED BY OTHERS

Several planning reports and water resources investigations have been undertaken which have recommended water supply projects in the outlying areas or have at least explored the potential of alternatives for the jurisdictions to consider. Some of this information has been developed by or for the counties, whereas some has been developed by state or federal agencies, most notably, the U.S. Geological Survey in the instance of groundwater resources. The following sections summarize the most significant contributions that have more recently been developed for these areas. This information is intended to supplement the data developed for this study presented in later section of Appendix I.

FAIRFAX CITY SERVICE AREA

Four reports have been prepared which are applicable to the Fairfax City Service Area. The first was a Comprehensive Plan for Loudoun County prepared in the early 1970's which assessed future water and sewer needs for both the western and eastern portion of Loudoun County. It was observed that Goose Creek would remain as the primary source of supply for the LCSA portion of the Fairfax City Service Area, and that with both proper conservation management and development of additional reservoirs the LCSA's needs could be met beyond 1990. The report also recognized that the Potomac River could assure the area a future source of water supply if and when the Goose Creek system reached its maximum water supply capacity.

In keeping with the philosophy set forth in this early planning document, a second report titled, City of Fairfax Water Supply System Improvement Project Engineering Report (February 1977) was prepared by Gannett Fleming Corddry and Carpenter, Inc. for the City of Fairfax. This report contains specific information on the alteratives for increasing the capacity of the Goose Creek Water Treatment Plant and the transmission system. Alternate plans and project costs for expanding the facilities over 10 years were presented in this report, and as a direct result the Goose Creek Treatment Plant and intake has been expanded from 9.5 mgd to a 27 mgd maximum rate.

In 1979, a Resource Management Plan was developed by Loudoun County which set forth policy to implement planning goals in the County. Although no prescribed program was set forth in this document to meet the LCSA's needs, the report cited the potential for the area to secure an adequate emergency supply from the FCWA in view of the FCWA's future capability to withdraw and treat Potomac River water near the Loudoun/Fairfax County line south of Route 7. At the present time Loudoun County has only an informal agreement for emergency supplies from this source.

The last major study discussed here which has application to the Fairfax City Service Area, although was not prepared specifically to address problems in that area, was Water Supply Storage for Washington Metropolitan Area prepared by Black and Veatch, April 1974. This study reviewed numerous available reservoir sites within 40 miles of Washington, DC in the Maryland and Virginia suburbs which were capable of augmenting low flows in the Potomac River. Twenty-one of 50 original sites were selected for further study by Black and Veatch based on level of development in the areas in question (Figure I-13). These sites were reviewed for the applicability to the Potomac River users

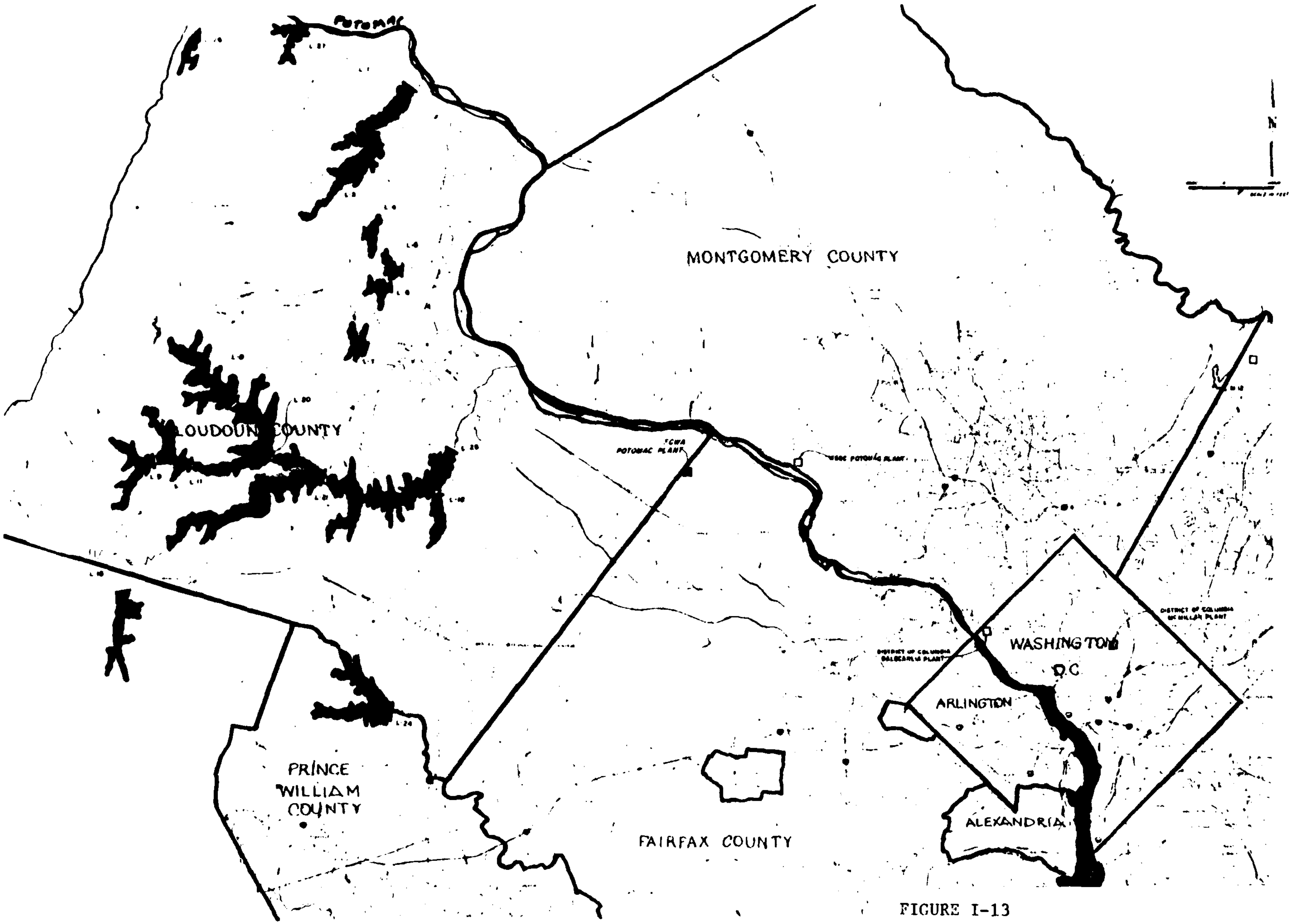


FIGURE I-13

POTENTIAL RESERVOIR SITES IN NORTHERN VIRGINIA (BLACK AND VEATCH)

in Appendix F of this report. Data on the Virginia sites which would be applicable to the Fairfax City service have been extracted from Appendix F and presented in Table I-24. Although these sites have been sized to utilize the full storage capability of each location and therefore do not match the exact water supply needs of the Fairfax City Service Area, they do serve to identify locations for potential storage development which this service area could take advantage of at some future date. All of these sites are located within the Goose Creek watershed and with the exception of L-25, all represent high flow skimming projects which would require pumpover pipelines from the Potomac River. No action has been undertaken to develop any of these sites by the Fairfax City Service Area to date because of one, Loudoun County's goal of maintaining the high quality natural environment associated with these areas, and two, the fact that the near term needs of this service area can be met with existing sources.

LOUDOUN COUNTY SERVICE AREA

The need for adequate water supplies in the western portion of Loudoun County has been recognized as a problem for sometime. In general, the water supply sources from wells, springs and mountain reservoirs in Loudoun County have been able in the past to supply the rather limited needs of small communities; however, recent shortages during extended dry periods have created problems in many communities. A study entitled Future Water Supply in Western Loudoun County Virginia, December 1977 prepared by Betz, Converse and Murdoch, Inc. determined that the water supplies of 3 major communities in western Loudoun County including Hamilton, Round Hill and Purcellville were inadequate to meet their own future demand, let alone that of a regional system which was being contemplated. The study investigated a range of alternatives to meet future demands including wells, the Potomac River, the Shenandoah River, local reservoirs, and purchasing water from the FCWA.

The study presented two major conclusions: 1) the least costly and most reliable regional water supply service involved the immediate construction of a locally funded water supply reservoir on the Catoctin Creek with attendant transmission and water treatment facilities, and 2) a regional water service system (either the existing LCSA or a new regional entity) would provide the most practical institutional arrangement for implementing the recommended solution.

The Catoctin Creek site was initally investigated under PL 566 Program by the US Soil Conservation Service (SCS) as part of the Catoctin Creek Watershed Plan. A multiple purpose reservoir project was originally proposed. This project with a 16 square mile drainage area could provide sufficient yield to meet the projected water supply demands of western Loudoun County. The estimate of the potential yield of the project was 8.7 mgd and total cost of the project excluding transmission costs was estimated to be $2,900,000 based on May 1977 prices.

The Loudoun County Municipal Water Needs recommended that the proposed SCS project be modified by eliminating the flood control storage. The reason for the modification was that the modified project could be built by the local jurisdictions without Federal involvement. This was cut down the review, approval and appropriation procedures which would otherwise take many years. The estimated cost of the modified project, based on May 1977 prices was $1,600,000. Under the modified (single purpose) proposal, each town would control the distribution system within its jurisdiction and a central body would be set up to take charge of the common source. The proposal was never implemented because the towns did not want to reliquish their control to a central body.

TABLE I-24

CHARACTERISTICS OF SELECTED RESERVOIR SITES IN GOOSE CREEK WATERSHED[1]

		Drainage Area	Dependable Runoff, MG	Net Storage MG	Yield (MGD)	Cost/MGD[2] $\$x10^6$
L-8	N. Fork Goose Creek	23.6	1,080	9,630	31	3.03
L-9	Beaverdam Creek	22.4	1,025	7,790	24	3.40
L-11	Beaverdam Creek	38.4	1,757	7,140	21	3.62
L-20	N. Fork Goose Creek	95.0	4,347	39,100	125	1.50
L-21	Goose Creek	268.0	12,265	62,100	220	1.35
L-25	Goose Creek	357	16,064	5,720	20	5.74
L-15	Cromwell Run	18.1	908	5,030	18	3.71

[1] Based on Black and Veatch Report, April 1974.
[2] Costs included costs for pumping, updated to October 1981 price levels.

Several remaining alternatives were also set forth for consideration in meeting interim and long term needs. The alternatives for meeting long term needs are summarized in Table I-25. The study also concluded after a review of existing and potential well resources that ground water was not of sufficient quantity or reliability to serve as a water supply source for this region.

TABLE I-25

POTENTIAL LONG RANGE SOLUTIONS FOR WESTERN LOUDOUN COUNTY (BETZ, CONVERSE, MURDOCH, INC.)[1]

ALTERNATIVE	ESTIMATED CAPITAL COST ($Mill)[2]	ESTIMATED O & M ($Thousands)[2]
Potomac River Pumpover	3.4 to 4.1	120 to 150
Shenandoah River Pumpover	3.7 to 4.4	170 to 190
North Fork Catoctin Ck Reservoir	3.2 to 3.9	80 to 110
Blue Ridge Mt. Sites (Purcellville)	4.8 to 5.5	60 to 70
Purchase From Fairfax City	3.2 to 3.9	610 to 670
Wellfield Near Leesburg	None	None
Groundwater	Not Recommended	

[1] Future Water Supply In Western Loudoun County, Virginia, December 1977.
[2] Updated to Oct 1981 price levels.

As in the case of the Fairfax City Service Area, the Black and Veatch report discussed earlier also has application to the remaining portions of Loudoun County. In addition to the reservoir sites listed in Table I-24, an additional seven sites listed in Table I-26 and shown in Figure I-13 were also identified in Loudoun County. To date, no storage impoundments have been constructed or are planned for construction at these locations.

In a comprehensive survey of public water supply in Northern Virginia, conducted by the Virginia State Water Control Board, it was reported that the Towns of Hamilton and Round Hill were experiencing reductions in well yields and shortages, respectively. Furthermore, water quality of these sources was reported to be poor and in the case of Round Hill, suspect to contamination.

PRINCE WILLIAM COUNTY SERVICE AREA

County concerns for water supply have prompted several investigations of possible water supply sources. Among these studies were a series of supply reports done by Wiley & Wilson, Lynchburg, Virginia and some groundwater studies.

The series prepared by Wiley & Wilson date from 1966 to 1978. Four reports were released, the last three updates of the original 1966 study. Table I-27 gives a brief synopsis of the alternatives examined and the recommendations made in each report. Some of the studies recommended further investigations.

The Wiley and Wilson report of December, 1978 was a much expanded version of the earlier studies and represents the latest effort the county has taken to plan for future water supply needs. The study offered alternative plans involving various projects to satisfy future county needs. The projects included impoundment, further development and expansion of existing sources, and the purchase of water from the FCWA. The alternatives considered include:

1. Bull Run Impoundment
2. Cedar Run Impoundment
3. Little Bull Run Impoundment
4. Prince William Forest Park Impoundment
5. Expansion of Lake Jackson
6. Expansion of Lake Manassas
7. Groundwater development
8. Purchase from Fairfax County Water Authority

Six alternative plans were coordinated from the proposed projects to satisfy county needs projected to the year 2000. Each of these plans were rated as to their reliability and probability for implementation, and preliminary costs were developed for each alternative. Conservation alternatives were not considered among the structural projects in this study. None of these plans included the construction of Little Bull Run Impoundment.

TABLE I-26

CHARACTERISTICS OF SELECTED RESERVOIR SITES IN LOUDOUN COUNTY, VIRGINIA

SITE	LOCATION	DRAINAGE AREA (Square Miles)	NET STORAGE (MG)	DEPENDABLE RUNOFF (MG)	YIELD (MGD)	COST/MGD $\$K10^{6*}$
L-1	Catoctin Ck	91.5	12,400	9,880	50	1.23
L-4	Trib of S. Fork Catoctin Ck	1.8	1,210	84	4	6.33
L-5	Limestone Br	1.2	1,710	53	4	5.99
L-6	S. Fork, Limestone Br	2.3	3,100	104	9	2.96
L-7	Tuscorora	4.5	1,650	204	7	6.38
L-26	Piney Run	12.4	2,810	590	10	2.60
L-27	Dutchman Ck	12.9	3,610	600	12.5	2.77

* October 1981 dollars.

TABLE I-27
SUMMARY OF PREVIOUS STUDIES
PRINCE WILLIAM COUNTY, VIRGINIA

Study	Projects Studied	Recommendations
A comprehensive Report of Future Water Supply (Wiley & Wilson, Lynchburg, Virginia, April 1966)	Kettle Run Impoundment	Eliminated
	Little Bull Run Impoundment	Eliminated
	Chestnut Run Impoundment	Eliminated
	Broad Run Impoundment 3 site locations	Site Located at Brentsville Treatment facilities
	Lake Jackson	Recommended
	Salem Church Reservoir	Recommended
	Cedar Run Impoundment	Recommended
Wiley & Wilson Update - July 1968	Salem Church Impoundment	Recommended
	Cedar Run Impoundment, Brentsville	Recommended
Wiley & Wilson Update - Jan 1977	Lake Jackson	Cost Update
	Cedar Run, Impoundment Brentsville	Cost Update & Status Report
Water Resources Evaluation for Prince William Co., VA (Wiley & Wilson, Dec 1978)	Groundwater Development	Recommended
	Cedar Run Impoundment	Recommended
	Bull Run Impoundment	Recommended
	Little Bull Run Impoundment	Eliminated
	Prince William Forest Park	Recommended
	Expansion of Lake Jackson	Recommended
	Expansion of Lake Manassas	Recommended

The Cedar Run project has been pursued perhaps the most vigorously of the all the projects considered since 1966. In 1977 the County submitted an application for a permit to construct the project with the Corps of Engineers pursuant to Section 404 of P.L. 92-500. On 26 September 1978, the Baltimore District Corps of Engineers informed Prince William County that the issuance of a Department of the Army permit would not be possible at that time for the following reasons: (1) lack of sufficient information as required by the permit application; and (2) objections to the project from the United States Marine Corps Quantico Marine Base, which would be partially inundated in some areas if the project was constructed. It was also stated that should the Marine Corps express its approval of this project, Prince William County could resubmit its permit application to the Baltimore District. These issues have not been resolved to date.

As part of the latest Wiley and Wilson effort, (December 1978), a parallel study was subcontracted to Geraghty and Miller, Inc., which involved a preliminary survey of the potential for developing additional supplies of groundwater in the county and to recommend areas where such developments would be feasible. The study, Availability of Groundwater For Public Supply in Prince William County, Virgina, December 1978 found from preliminary data that the Triassic formation could potentially provide an additional 10 to 15 mgd and the Cretaceous (Coastal Plain) Aquifer at least several mgd. The study recommended a drilling and testing program for the Triassic area and controlled aquifer tests at one or more of the existing well fields in the Cretaceous aquifer.

CHARLES COUNTY SERVICE AREA

With little exception the development of groundwater has been the traditional method by which the county has met its water needs in the past and plans to meet its needs in the future. In more recent years (for example -mid 60's drought), multiple well failures have occurred in existing wells, particulary in the more heavily pumped aquifers around LaPlata. The general response to well failures has been to search for more prolific sites some of which have required larger and deeper wells. According to the Charles County Comprehensive Water and Sewer Plan, 1977 supplies should remain adequate in the future, however, protection of the recharge areas would be important as urbanization reduces open land.

Both the US Geological Survey and the Maryland Geological Survey have been active in assessing the groundwater resources of Charles County. In 1968, these two agencies jointly published a technical report entitled Availability of Groundwater in Charles County. This report was prepared at the request of the Charles County Commissioners in response to their concern about the adequacy of the existing groundwater supplies to satisfy the increasing water requirements of population growth, and industrial and agricultural expansion.

The general findings that evolved from the detailed investigation were: a) based on rough estimates, the major aquifers underlying the County (Aquia Greensand, Magothy, Patapsco/Raritan, Patuxent) may be capable of yielding 55 mgd of water from properly spaced drilled and dug wells; b) an appraisal of the groundwater available from five areas of anticipated future economic and population growth indicated that about 3 mgd of groundwater could be obtained in the area of lowest potential (in the northwest) to about 16 mgd in the area of greatest potential (Waldorf); and c) the Waldorf area appeared to be most favorable for the development of large additional supplies.

The State of Maryland considers Charles County and adjacent St. Mary's County to be the highest priority areas for the development of comprehensive water resource plans within the State of Maryland, primarily because of the high growth rate these areas have been experiencing in the last decade. In fact, a water appropriation permit recently granted to Waldorf was conditioned with a request by the State that Charles County develop a comprehensive plan for the orderly development of groundwater. Presently, a multi-disciplinary interagency group including local utilities, the USGS, and the Maryland Geological Survey, are imbarking on a study including test drilling to comply with the State's desires. Results of this study will be further developed by the State at some future date in an overall sub-basin plan for the southern Maryland area.

In addition to the work on groundwater there has been, to a limited extent, some interest in the development of potential surface water (impoundment) sites in Charles County. In general the potential for the development of significant storage sites for water supply is minimal in Charles County due primarily to topographic limitations as well as environmental considerations of inundating its many valuable marshlands and wetlands. The Soil Conservation Service identified 72 potential impoundment sites within Charles County as part of the 1968 Maryland Water Impoundment Inventory of Potential Impoundment Sites. In 1973, this inventory was updated by the Southern Maryland Research Conservation and Development Board with more detailed information provided for those sites in Charles County. As a result of this inventory, no official action was taken by the County to preserve these potential sites or to further update or refine the inventory. On the local level, however, the Town of LaPlata used this inventory as a

means of identifying potential sites which could serve to supplement its existing groundwater supply. The Town's interest was prompted by the failure of several of its wells during the drought which occurred in the mid-1960's. A feasibility study was performed for the Town by the Southern Maryland Research Conservation and Development Board. Table I-28 lists the sites investigated by the Board. Included in this table is the preliminary engineering data as originally developed. The sizing of each project was based on demand data provided to the Board by the Town for the year 2000. A location map of each project is given in Figure I-14. All of these sites are tributary to either the Wicomico or Port Tobacco Rivers, both of which have been designated as State Scenic Rivers.

TABLE I-28

LAPLATA WATER IMPOUNDMENT SITES[1]

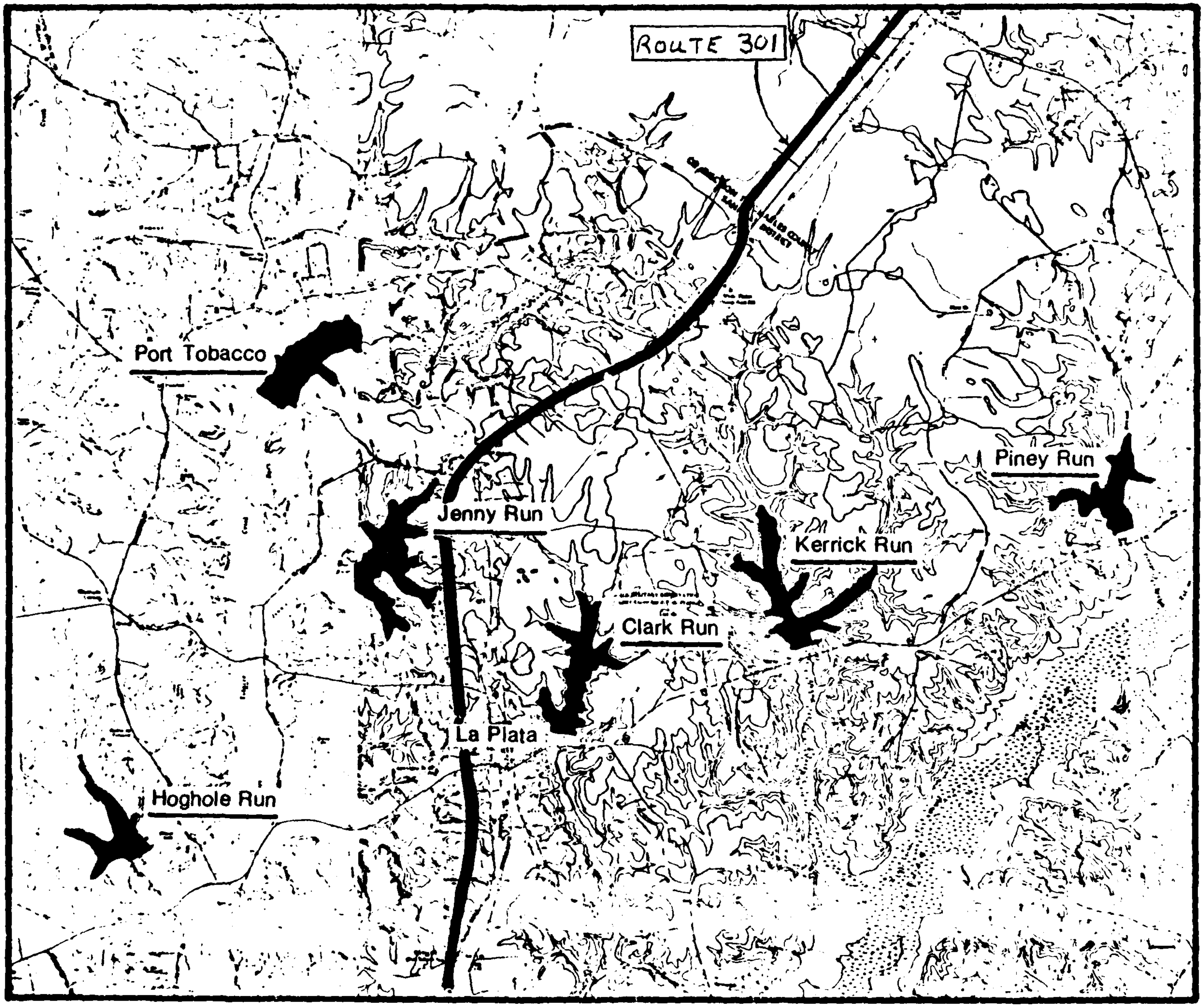
	Height of Dam (MSL)	Drainage Area (Sq. Miles)	Yield (MGD)[2]	Water Supply Storage (acre ft.)	Construction Cost Estimate ($000)[3]
Clark Run	44	3.4	1.31	1,476	870
Kerrick Run	46	8.3	1.31	641	827
Hoghole Run	63	3.4	1.31	1,476	995
Port Tobacco Creek	45	5.1	1.31	1,050	1,050
Piney Creek	47	6.7	1.31	740	888
Jennie Run	56	3.3	1.31	1,515	682

[1] Feasibility study prepared by USDA-SCS, June 1974.
[2] Projects are sized to meet year 2000 demands.
[3] Updated to October 1981 dollars.

ALTERNATIVES AVAILABLE FOR THE OUTLYING SERVICE AREAS

The previous sections have shown clearly that an array of water supply projects have been considered by some of the utilities and political entities (at varying governmental levels) within the outlying service areas. Some projects have been implemented, while others are at various stages of planning. Typically, water supply planning in these areas is geared to a shorter planning period (perhaps as far as the year 2000 in most cases) than the 50 year planning horizon set for the MWA Water Supply Study. Furthermore, because

FIGURE I-14
LOCATION OF SCS PROJECTS - LA PLATA, MARYLAND



of the shorter planning horizon, much of the planning has been done on a piecemeal basis, that is, individual plans or projects have been developed for individual utilities or municipalities. Because of this, the potential benefits of regionalization of resources has not been fully explored. Only in recent years has the concept of regionalization of supply sources been seriously considered, but only in certain areas. The previous section of Appendix I dealing with phasing of subareas to be served by public systems serves as one scenario for the progressive aggregation of subareas to be served by public systems by the year 2030. The degree to which these areas may be served by more centralized regional systems and if and when this might occur will vary dramatically from one region to another and will depend largely on the ability and the desire of the political entities involved to enter into such agreements. Because of this uncertainty, the following information is presented to provide the outlying areas with planning information on water supply alternatives which may assist them regardless of how or if regionalization occurs in the future. Using the projected demands developed earlier as a guide as to the rate and overall magnitude of need which could reasonably expected in these areas in the future, varying alternatives are set forth along with an estimate of their ability to meet the range of needs with the methodology used to develop conservation programs for the MWA Water Supply Study.

Alternatives for the outlying areas have been subdivided into two categories: those which maximize the use of existing resources and those which require development of additional sources.

ALTERNATIVES TO MAXIMIZE USE OF EXISTING RESOURCES

Alternatives to maximize the use of existing resources include those to reduce or regulate demand such as water conservation and water pricing as well as the exchange of water via new interconnections between systems or purchases of additional water using existing interconnections.

WATER CONSERVATION

Water conservation is a means of decreasing the use of water thus allowing more efficient use of available supplies. A rather detailed conservation program was developed for the service areas addressed as part of the MWA Water Supply Study because of the recognized importance of this approach in overall water supply planning. Appendix G, Non-Structural Studies provides in detail the methodology used to develop conservation programs for the MWA Water Supply Study. The conservation measures developed for this study include measures to reduce water use over the long term as opposed to short term reactionary measures which are often implemented during emergency periods. In order to evaluate the potential of conservation to reduce the baseline demand projected for the future, five water conservation scenarios were developed. The scenarios differ according to the degree of user participation, the rates of effectiveness attributable to the demand reduction devices employed, the water use characteristics of the area targeted, and the number and type of demand reduction devices included. The scenarios developed are additive, that is, each level of reduction considered includes the devices and levels of reductions achieved by the previous scenarios.

The baseline scenario incorporates new or anticipated plumbing regulations in the MWA which were implemented by 1980. This condition was considered to be the most probable one given no further conservation efforts.

Scenario 1 is the least intensive of the five conservation scenerios that were developed. It is oriented strictly towards indoor residential water use. Water saving devices would include those developed for the baseline scenario as well as pressure reducing valves, pipe insulation, water-efficient clothes washers and dishwashers, toilet modifications, shower modifications and other non-structural modifications.

Scenario 2 builds upon techniques contained in the preceding program. It adds to them by assuming reductions in outdoor residential use. Non-structural modifications would be implemented primarily in the form of education compaigns to reduce demand.

Secenario 3 includes non-structural measures, mainly education, to be aimed at non-residential users.

Scenario 4 is aimed at reducing loss in unaccounted for water. This would include loss due to leakage, inaccurate meter readings, water used for municipal purposes, water used for system maintenance, and loss due to system deterioration.

Scenario 5 is the most intensive of the scenarios. It involves implementing water saving devices in both new and old residences.

Figures I-15 through I-18 illustrate the relative effectiveness of each of these water conservation scenarios on the baseline (without conservation) condition for the Fairfax City, Loudoun County, Prince William County, and Charles County Service Areas, respectively. The most optimistic and the most stringent conservation program, Scenario 5, is projected to reduce average annual water demands by the year 2030 by approximately 27 to 41 percent, varying according to the different service areas. A more realistically achievable and implementable scenario represented by Conservation Scenario 3 is projected to reduce demands by about 10 percent, 11 percent, 6 percent, and 10 percent, for the Fairfax City, Loudoun County, Prince William County and Charles County Service Area, respectively.

Table I-29 summarizes the total capital costs to implement Conservation Scenario 3 for the period 1980-2030 in each of the outlying service areas. These costs were developed based on the number of single and multiple-family dwelling units projected for each service area which was in turn related to the unit costs for water saving devices as well as costs for nonstructural modifications. A complete description of the units costs used as a basis for these costs are present in <u>Appendix G, Non-Structural Studies.</u> It is noted that the costs for conservation programs without pressure reducing valves (prv) and insulation are significantly less than costs with these improvements. Furthermore, prv's and insulation account generally for only 1 to 2 percent of the overall reduction achievable and therefore their cost-effectiveness is questionable from a demand reduction viewpoint.

FIGURE I-15

CONSERVATION DEMAND LEVELS

FARIFAX CITY SERVICE AREA

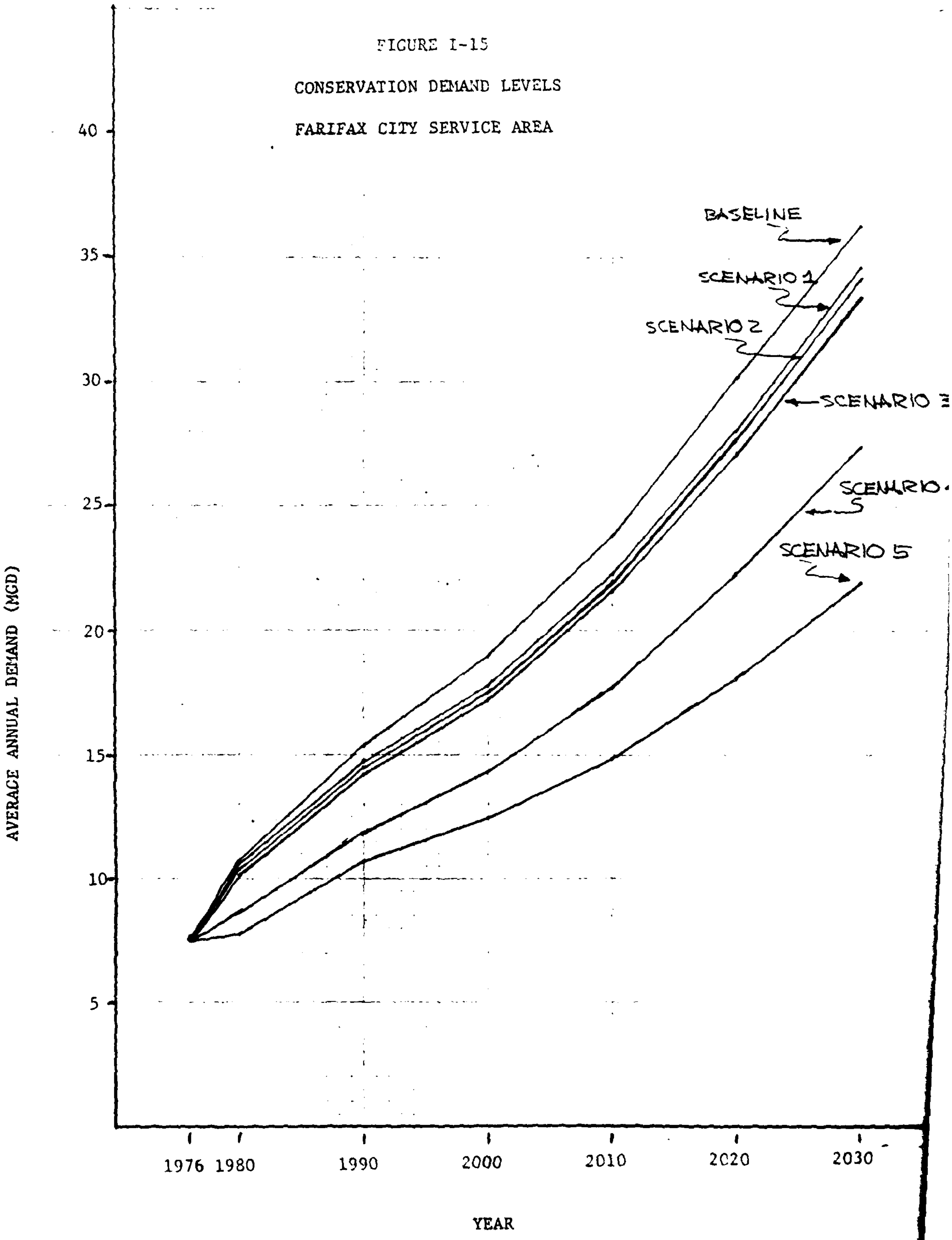


FIGURE I-16

CONSERVATION DEMAND LEVELS
LOUDOUN COUNTY SERVICE AREA

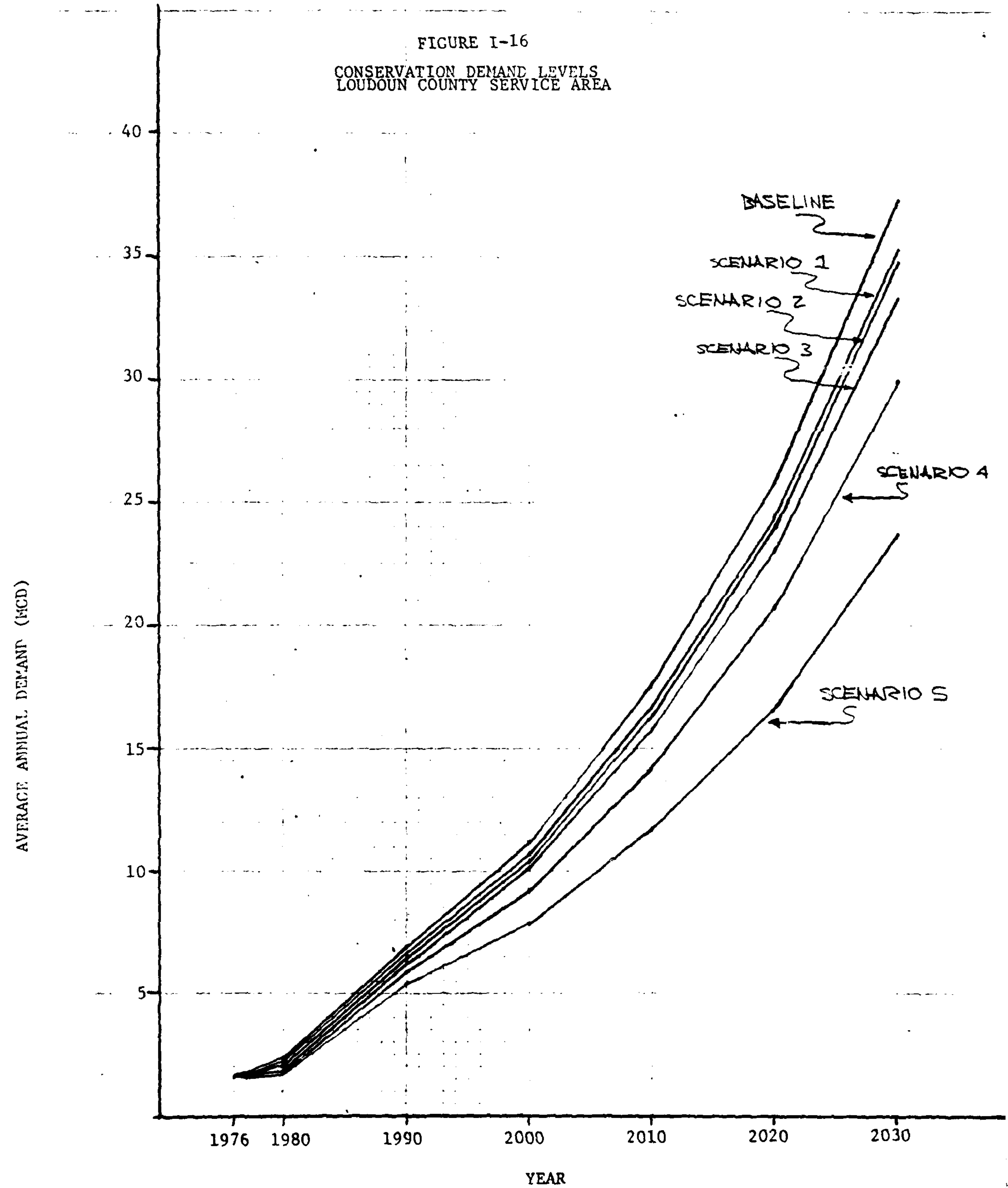


FIGURE I-17
CONSERVATION DEMAND LEVELS
PRINCE WILLIAM COUNTY SERVICE AREA

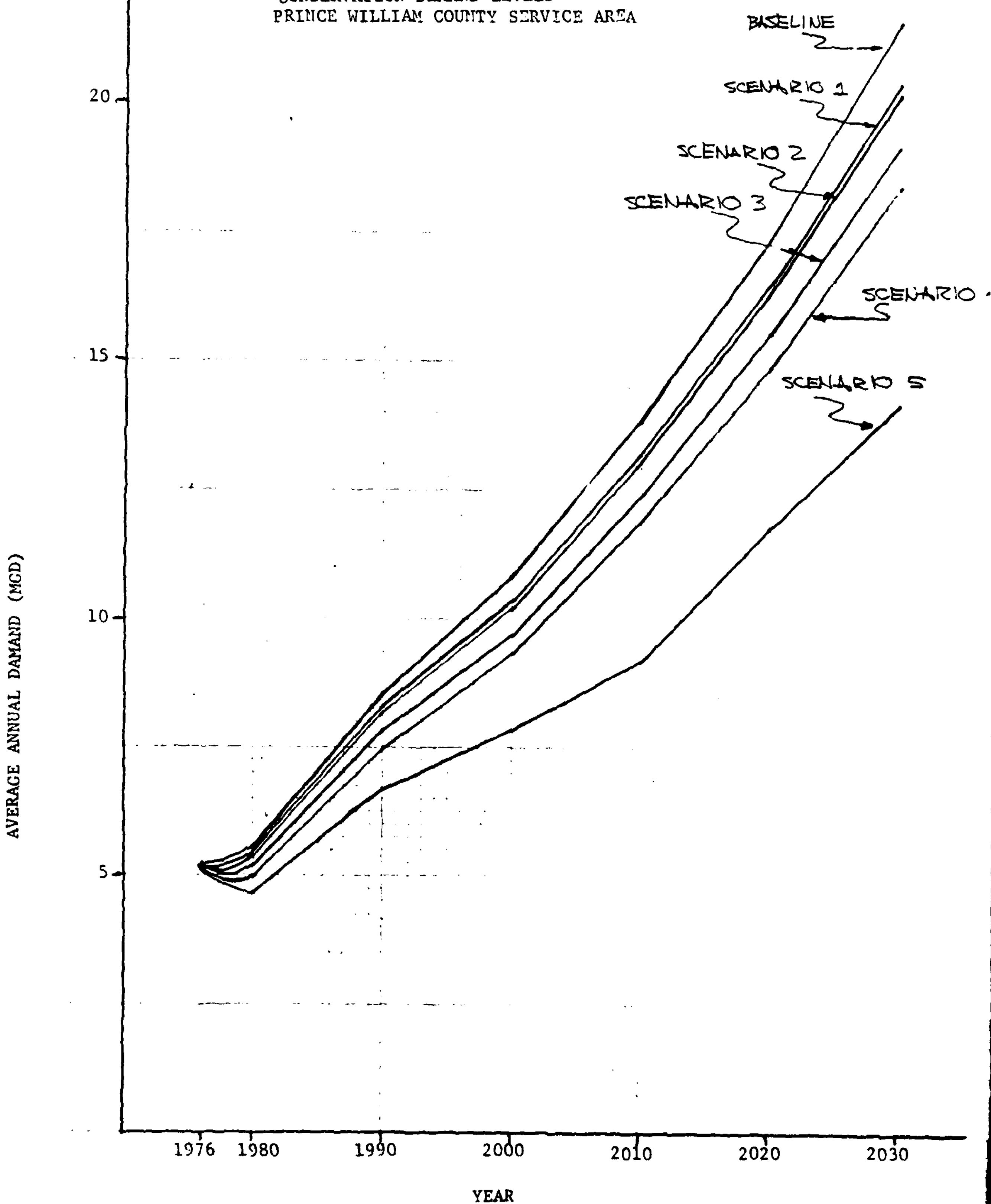


FIGURE I-18
CONSERVATION DEMAND LEVELS
CHARLES COUNTY SERVICE AREA

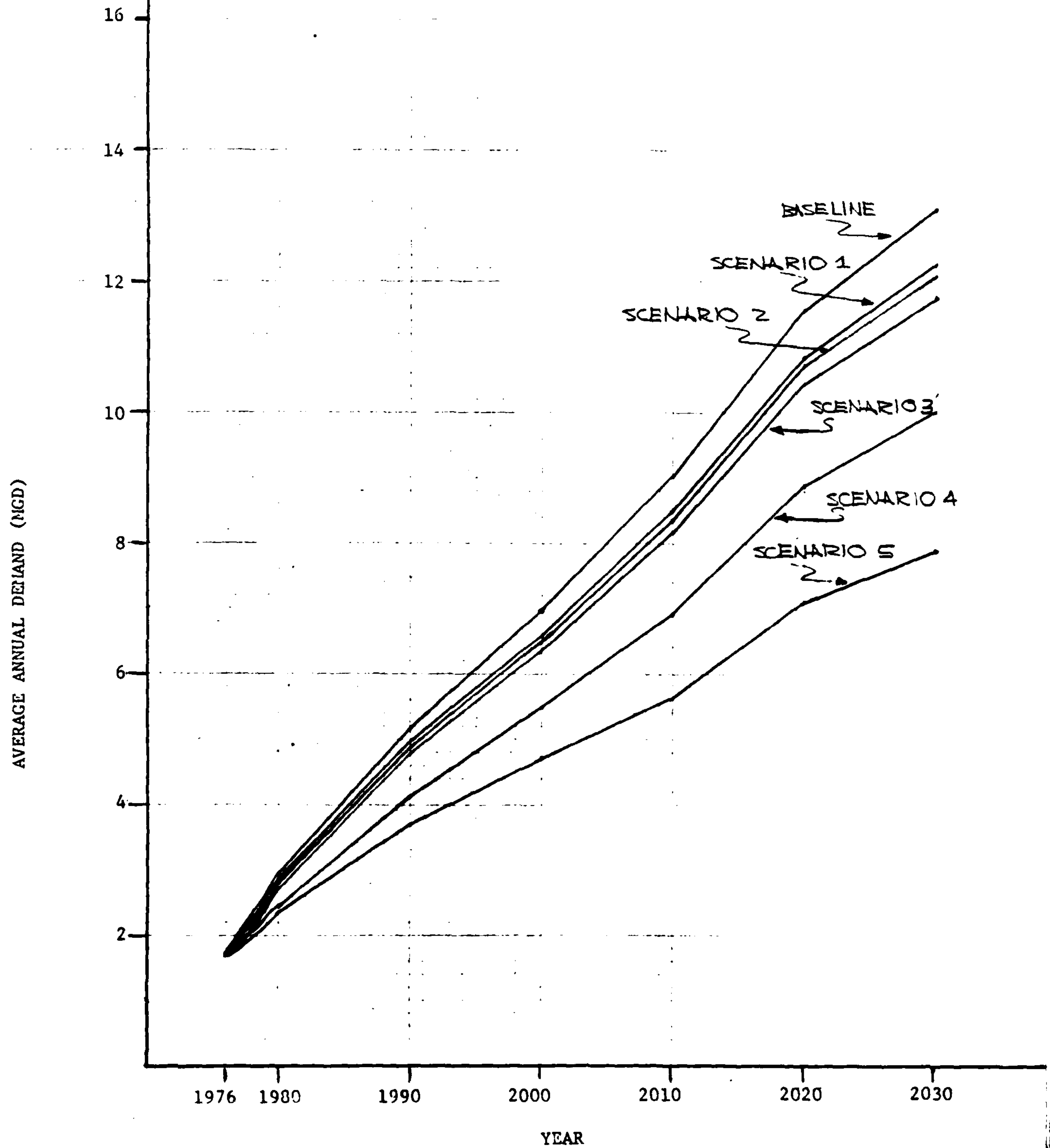


Table I-29

SUMMARY COSTS OF CONSERVATION SCENARIO 3*

SERVICE AREA	TOTALS w/o PRV's AND INSULATION	TOTALS w/PRV's AND INSULATION
Fairfax City	540,000	7,640,000
Loudoun County	250,000	7,802,000
Prince William County	285,000	7,933,000
Charles County	270,000	3,710,000

* Capital costs in October 1981 Dollars for costs incurred 1980-2030.

The most important conclusion to be derived from this analysis is that the conservation scenarios serve only to reduce demand to a certain level at which point either existing sources are adequate to meet the reduced demand or additional sources are required. A major benefit of conservation therefore is to reduce demand to the point that the need for additional supplies is delayed in time and/or the quantity or size and cost of projects developed for new supplies can be significantly reduced. Furthermore, conservation involves little, if any, environmental impact. As a long term program, little if any social disruption or sacrifice would be involved other than the cost of installing conservation devices in residences and businesses.

WATER PRICING

One additional method of reducing the demand for water which was explored as part of the MWA Water Supply Study was water pricing. This investigation is presented in its entirety in Annex G-II of Appendix G, Non-Structural Studies. The primary objectives of the water pricing study were to:

a) determine the effectiveness of price and pricing (rate) strategies in reducing water demand and evaluation their impacts; and
b) to develop concepts for better pricing, measure the impacts of price changes, and determine their feasibility for implementation.

The principal focus for the investigation was the major Potomac-dependent utilities in the MWA; however the study also included a survey of 12 smaller utilities which lie within the outlying service areas. Table I-30 lists those utilities surveyed as part of the water pricing investigation.

Table I-30

OUTLYING SERVICE AREA UTILITIES
SURVEYED IN PRICING STUDY

Fairfax City Service Area
Loudoun County Sanitation Authority
City of Fairfax
Town of Herndon

Loudoun County Service Area
Town of Leesburg

Prince William County Service Area
City of Manassas
City of Manassas Park
Town of Quantico
Greater Manassas Sanitary District

Charles County Service Area
Town of LaPlata
Town of Indian Head
Charles County

The investigation was based on the premise that peak period marginal cost pricing (the opportunity cost of resources used to provide water in peak periods) provided the most efficient and equitable means to evaluate pricing in the MWA. As such, the investigation involved several steps which are summarized below:

a) the development of a data base of cost information relative to source development, treatment, transmission, O&M, fixed costs, etc., for both water and sewer.

b) the reorganization of the information developed in item a above in terms of peak and non-peak use.

c) development of a 3-tiered rate structure including a fixed charge, commodity charge, and peak use charge based on the date organized in item b, above.

d) the development of future water costs in terms of the newly developed 3-tiered structure. Information provided by the utilities formed the basis for these costs.

e) a determination of whether or not the pricing scheme developed from steps a-d, above was successful in reducing demands.

The results of the pricing investigation for the outlying areas were similar to those derived for the major Potomac-dependent utilities. The principal finding was that the near-term demand forecasts for these areas would not be further reduced by better pricing policies because:

a) A high proportion of fixed costs in these utilities (an average of about 38%, Figure I-19) has the effect of keeping marginal cost peak period rates below rates from present pricing and,

b) High quality well water and low associated treatment costs have the effect of causing relatively little escalation in the long-run marginal cost for water and thus diminishes the effectiveness of peak period marginal cost pricing. (Figure I-20).

Another important finding of this study pertinent to the outlying service areas was that the most popular rates in these areas include uniform and block rates and that for both, the average price tended to approximate the average cost. Figure I-21 shows the average cost forecasts for the non-Potomac utilities. It was also found that the City of Manassas was the only outlying utility surveyed which showed a peak quarter rate above average cost. This may be attributable to its more expensive reservoir supply source when compared to well water sources of other utilities and the degree of detailed information the utility was able to provide for the pricing analysis.

INTERCONNECTIONS AND/OR PURCHASE FROM EXISTING SYSTEMS

A third method of meeting the future need for water in the outlying areas is to utilize the resources and facilities of nearby systems which may have excess capacity. This might be accomplished in a variety of ways including: a) infrequent emergency transfer of water during peak periods, b) regular service during the greater part of the year when abundant supply is available from the "seller" thus preventing the "buyer" source from being depleted during peak periods, and c) future integration, aggregation, and centralization of the resources of smaller utilities for the benefit of a larger region.

The primary benefits of any of the above methods is the greater efficiency that can be derived by maximizing the use of available supplies and facilities. This can be accomplished generally at a lower cost and lower risk of environmental or social impacts than what otherwise would be associated with the development of new water supply sources. The greatest drawback of any of these methods is that none result in any net supply increase and the degree of success of any of the approaches is constrained by a finite water supply base.

Table I-31 summarizes an array of possibilities which exist for the interconnection of the various utilities within a service area as well as between service areas. The newly developed Potomac River source for the Town of Leesburg could be used by the LCSA or other communities and developments around Leesburg. Leesburg officials have indicated that there would be potential surplus capacity available to other users in the future. LCSA's main along Route 7 is very close to Leesburg's main along Route 773. An interconnection in this area would not require any pumping. However, LCSA may not want to use water from Leesburg's facilities because of its high cost. Conversations with the officials responsible for operations of these system in 1980 indicated that the cost of the Leesburg's water to LCSA would double the cost for water that the LCSA was paying to Fairfax City. However, as the developable resources become scarce in the future and the demands for water increase, the cost of Leesburg's water might become comparable.

FIGURE I-19

FIXED COSTS AS A PROPORTION OF TOTAL COSTS

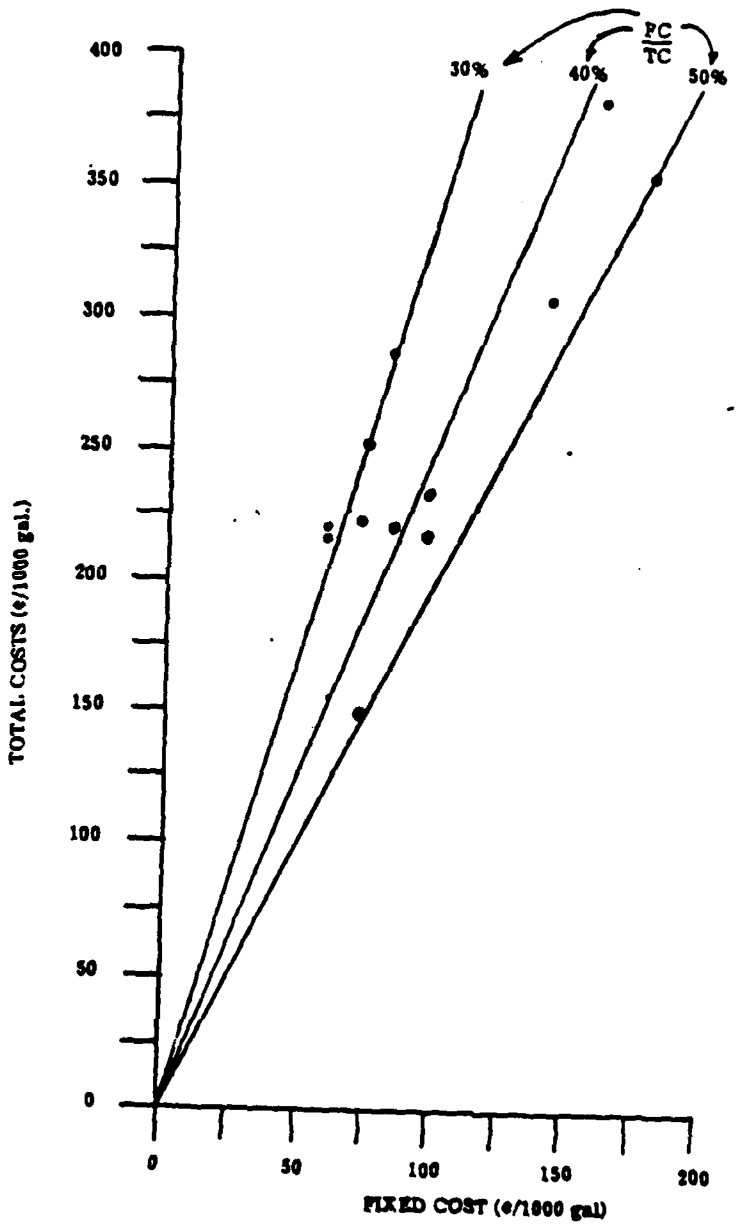


FIGURE I-20

WATER LONG-RUN MARGINAL COST FORECAST

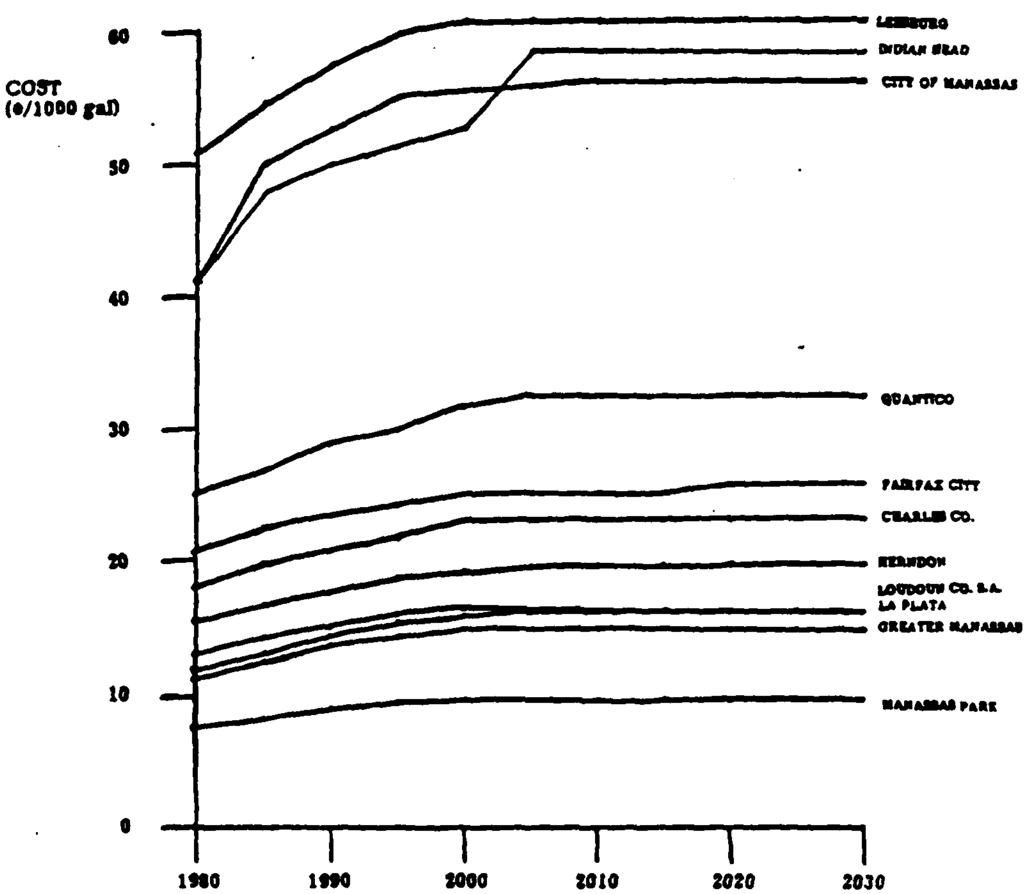


FIGURE I-21

AVERAGE COST PROJECTS

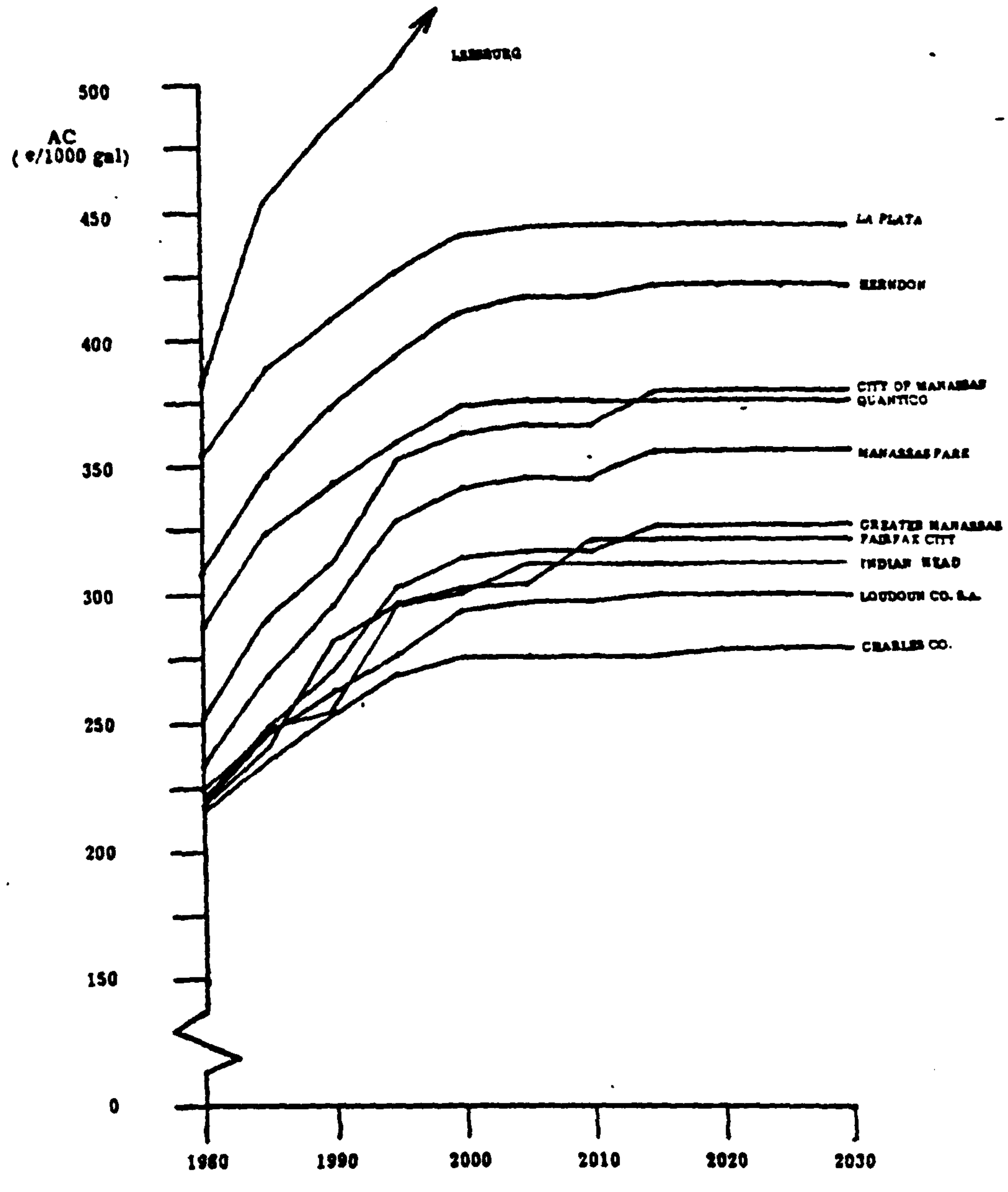


Table I-31

SUMMARY OF POTENTIAL INTERCONNECTIONS - OUTLYING SERVICE AREAS

Outlying Area/Sub-Area	Potential Source for Interconnection(s)	Expanded Use of Existing or New Interconnection Required	Benefit of Interconnection	Constraints
Fairfax City/LCSA	FCWA Potomac Treatment	Expanded use of existing interconnection/and or new interconnection w/Plant	Maintain reserve storage in Beaver-dam reservoir	Need would be greatest during periods when Potomac flows are lowest and with peak con-current need for FCWA
	Leesburg Potomac Plant	New interconnection	LCSA service area potential	Limited capacity high cost
Western Section Loudoun Co. Service Area (Hamilton, Purcellville, Round Hill, Hillsboro)	Leesburg Potomac Plant	New interconnections	Most practicable for closest communities to Leesburg (Hamilton Purcellville, Round Hill)	Limited capacity Limited application to only closest communities
	Fairfax Cit /LCSA	New interconnections	Most practicable for closest communities to LCSA served areas	Limited capacity of Goose Creek system

Table I-31 (Continued)

Prince William County	FCWA	Existing with OW/DT Sanitary District	Dependable reservior source Allow recharge of aquifers during non peak demands	Limited capacity, dependance on supply outside of county Water quality of source Limited to eastern sector of county
	GMSD-Broad Run Reservoir	Expand Emergency interconnections and fully utilize existing interconnections to serve all Sanitary Districts	Centralized regional source	Limited capacity Require expanded water treatment capacity
Charles County	Groundwater	New interconnections between 3 major sanitary districts and interspered public suppliers	Centralization of sources-Dependability Consistent w/county growth plan	~~Locations~~ Utilities must relinquish absolute control over independent sources
	WSSC	New interconnections	Northermost areas (Charles Co. Department public works) most attractive Allows recharge of aquifers during non-peak periods (i.e., Magothy) Dependability	Would require new negotiated agreement w/WSSC

The Towns of Hamilton, Purcellville, and Round Hill are located along Route 7 west of Leesburg. Currently, these towns obtain their supplies from groundwater. Because of uncertain groundwater yields and as groundwater sites becoming scarce, it could be difficult to meet the projected water supply demands for these towns from groundwater sources. One of the potential sources of supplies for these towns could be the Leesburg's surplus capacity at the Potomac Intake. Several miles of new pipelines along Route 7 and pumping stations would be required to implement this type of arrangment.

In the cases where either the FCWA or WSSC could provide an additional source of supply it should be recognized that the degree to which these service areas can supply adjacent communities is reduced during critical low flow periods in the Potomac and will continue to decrease in the future. Despite the fact that these major services areas have recently entered into agreements to assure adequate supplies for their futures, the ability of these areas to serve unanticipated, large new demand areas is less certain. Perhaps the best way for the major services areas to assist adjacent non-served areas would be during non-peak periods of ample Potomac River flow and low demand. During these periods, excess Potomac River flows and treatment capacity at the Potomac Plants could be utilized to serve either all or part of adjacent communities. This approach would allow adjacent communities with particularly troublesome supplies (i.e., declining water table in Waldorf, Charles County, failing groundwater supplies in Western Loudoun County) to reduce their dependency on these sources year round, and thus allowing them to be replenished for peak demand use.

In certain areas, the concept of further integration of sources and facilities would be more attractive than in others. Because of the many emergency interconnections which already exist between existing Prince William County utilities and because of the storage capacity in the Broad Run Reservoir, this approach might go a long way in relieving this area's dependence on well systems. As mentioned earlier, Charles County planners have incorperated the concept of regionalization of water and sewer services in the County's Comprehensive Water and Sewer Plan.

GOOSE CREEK/BEAVERDAM SYSTEM: A SPECIAL CASE

The Goose Creek/Beaverdam water supply system deserves special mention in this section regarding maximization of the use of existing resources because it represents the only source that provides the total supply for an entire service area. Because the Goose Creek/Beaverdam reservoir network represents a self-contained system, there exists the potential to increase its efficiency through improved management and/or by adding minor improvements to the system.

In order to identify the behavior of the existing system under projected demands, a drought simulation of the 1930-32 drought (the most severe monthly average low flow conditions on record for that basin) was taken. Using the low flow records available for that period, projected monthly demands (year 2030) were placed on the reservoir system to determine how they would behave if no other water supply projects other than those planned were available.

Table I-32 lists the important assumptions which guided this simulation. As indicated, both reservoirs were assumed full at the start of the simulation period. Inflows and losses were also computed. The 30-day demands placed on the reservoirs reflect MWCOG Round II population forecasts presented earlier in this appendix.

TABLE I-32
DROUGHT SIMULATION ASSUMPTIONS - GOOSE CREEK/BEAVERDAM RESERVOIR SYSTEM

STREAMFLOW:	1930-1932 monthly average flows for Goose Creek and Beaverdam Creek based on USGS Leesburg, Virginia, gaging station data (1930-1932). Drainage area relationship applied for Beaverdam Creek basin inflows.
RESERVOIR STORAGE:	a. Both Goose Creek and Beaverdam Reservoirs are full at beginning of drought, April 1930. 1. Goose Creek 200 mg Storage 2. Beaverdam 1340 mg Storage b. Evaporation losses and downstream releases from reservoirs equal to 2 and 1 mgd for Goose Creek and Beaverdam Reservoir, respectively.
DEMAND:	Year 2030 monthly average demands for the Fairfax City Service Area with no conservation programs exacted other than those legislated.
TREATMENT:	Simulation assumes unlimited treatment capacity to meet all demands.
OPERATION:	a. Goose Creek Reservoir. 1. Withdrawal at rate equal to demand. b. Beaverdam Reservoir. 1. Begin withdrawal from reservoir after Goose Creek Reservoir empties. c. Withdrawal rates from reservoirs are converted to storage equivalent (mg) and subtracted from previous month to develop new end-of-month storage.

Table I-33 presents the computational procedure for the drought simulation. A month-to-month evaluation of inflows minus withdrawals (which are converted to storage) was computed to first determine the remaining storage available in the Goose Creek Reservoir. Upon depletion of the Goose Creek Reservoir, the Beaverdam Creek Reservoir is drawn upon in a similar fashion. The existing or required storage appears in the final column of Table I-33. These values are plotted on the solid line in Figure I-14 which traces the storage of the Goose Creek and Beaverdam Creek Reservoirs over time.

Under the simulated condition depicted in Figure I-22, both reservoirs experience two periods of depletion; the first which is most severe, begins in the summer of 1930, followed by a brief recovery in the fall of 1931, which in turn is followed by the second

TABLE I-33

GOOSE CREEK/BEAVERDAM CREEK RESERVOIR SYSTEM
1930 DROUGHT SIMULATION

		Goose Creek Reservoir						Beaverdam Creek Reservoir					
MONTH/YEAR		VOLUME OF INFLOW (MG)	VOLUME OF DEMAND (MG)	TO STORAGE (MG)	FROM STORAGE (MG)	END OF MONTH STORAGE (MG)	UNMET DEMANDS (MG)	VOLUME OF INFLOW (MG)	TO STORAGE (MG)	FROM STORAGE (MG)	END OF MONTH STORAGE (MG)	UNMET DEMANDS (MG)	SURPLUS OR REQUIRED STORAGE (MG)
April	30	6,469	1,048	5,421	0	200	0	108	180	0	1,340	0	1,540
May	30	2,398	1,188	1,210	0	200	0	40	40	0	1,340	0	1,540
June	30	992	1,259	0	200	0	67	17	0	50	1,290	0	1,290
July	30	325	1,420	0	0	0	1,095	5	0	1,090	200	0	200
August	30	39	1,336	0	0	0	1,297	1	0	200	0	1,096	- 1,096
September	30	42	1,224	0	0	0	1,182	1	0	0	0	1,181	- 2,277
October	30	44	1,120	0	0	0	1,076	1	0	0	0	1,075	- 3,352
November	30	78	1,028	0	0	0	950	1	0	0	0	949	- 4,301
December	30	647	1,048	0	0	0	401	11	0	0	0	390	- 4,691
January	31	1,057	994	63	0	63	0	18	18	0	18	0	81
February	31	504	898	0	63	0	331	8	0	18	0	305	- 305
March	31	1,774	999	775	0	200	0	30	30	0	30	0	230
April	31	3,368	1,048	2,320	0	200	0	57	57	0	87	0	287
May	31	2,461	1,188	1,273	0	200	0	41	41	0	128	0	328
June	31	1,298	1,259	39	0	200	0	22	22	0	150	0	350
July	31	1,040	1,420	0	200	0	180	17	0	150	0	13	- 13
August	31	1,046	1,336	0	0	0	290	18	0	0	0	272	- 285
September	31	487	1,224	0	0	0	737	8	0	0	0	729	- 1,014
October	31	130	1,120	0	0	0	990	2	0	0	0	988	- 2,002
November	31	189	1,028	0	0	0	839	3	0	0	0	836	- 2,838
December	31	490	1,048	0	0	0	558	8	0	0	0	550	- 3,388
January	32	3,331	994	2,337	0	200	0	56	56	0	56	0	256
February	32	4,725	898	3,827	0	200	0	79	79	0	135	0	335
March	32	10,207	999	9,208	0	200	0	171	171	0	306	0	506
April	32	9,980	1,048	8,932	0	200	0	168	168	0	474	0	674
May	32	17,613	1,188	16,425	0	200	0	296	296	0	770	0	970
June	32	2,546	1,259	1,287	0	200	0	43	43	0	813	0	1,013
July	32	1,498	1,420	78	0	200	0	25	25	0	838	0	1,038
August	32	258	1,336	0	200	0	878	4	0	838	0	36	- 36

depletion in the summer of 1931. The simulation demonstrates the inadequacy of existing storage facilities to meet the project 2030 needs under a reoccurrence of the drought of record. An additional storage volume of about 4.7 billion gallons (bg) would be needed to relieve the deficits under this simulated condition.

The above scenario was tested considering two conditions: water conservation and the use of a Goose Creek/Beaverdam pumpover, to further determine the full capability of the existing system without implementing any major new projects. The storage curve represented by a dashed line in Figure I-22 shows the effect of implementing Conservation Scenario 3 (see previous sections) demands on the Baseline Condition. Although the storage depletion is reduced somewhat (by about 18 percent) the maximum storage required to eliminate shortages is still sizeable (about 3.8 mg).

Fairfax City currently has the capability to pump about 10 mgd from Goose Creek to Beaverdam Creek via raw water pipeline. This arrangment takes advantage of the disparity in seasonal flow between Goose Creek and Beaverdam Creek which is attributable to the great variation in drainage area. A potential way to maximize the use of excess flows in Goose Creek is to pump water to the Beaverdam Reservoir when it is drawn down. Although the existing pumping system has been in place since 1972 it has not been needed for this purpose to date. The simulation represented by Figure I-23 demonstrates the utility of unlimited pumpover capability with Conservation Scenario 3 demands in the year 2030. The figure shows that the major advantage of the pumpover is the reduction of storage depletion during the second summer of a prolonged drought. The pumpover however provides little benefit in eliminating shortages during the first summer and therefore has limited capability of providing an overall solution in meeting future needs. Fairfax City's plan of adding bascule gates to the Beaverdam Reservoir by 1984 will increase overall storage capacity of the system by about 0.5 billion gallons. Inspection of Figure I-23 reveals however, that this increase in storage will still fall far short of meeting 2030 needs.

In summary, water conservation, transfer of excess flows from Goose Creek to Beaverdam, and enlargement of Beaverdam Reservoir by 0.5 billion gallons can contribute to reducing shortages in the Fairfax City Service Area. However, even when considered in combination, these measures cannot meet the full water supply needs of this area in the year 2030 and signficant shortages will persist given the assumptions used in the previous scenarios. Supply augmentation from some additional source will be required. Potential sources for all of the service areas will be discussed further in the following sections.

ALTERNATIVES FOR WATER SUPPLY DEVELOPMENT

It is evident from the previous discussions that additional water supplies will be needed in the outlying service areas in the future in addition to whatever non-structural approaches are implemented. It is reasonable to group alternatives for water supply development into two broad categroies: a) primary alternatives - those alternatives which are most likely and promising in terms of potential yield and feasibility and, b) secondary alternatives - those which are technologically more complex, less promising in terms of potential yield, and less likely to be accepted.

FIGURE I-22

DROUGHT SIMULATION
GOOSE C[illegible]EEK/BEAVERDAM RESERVOIR SYSTEM

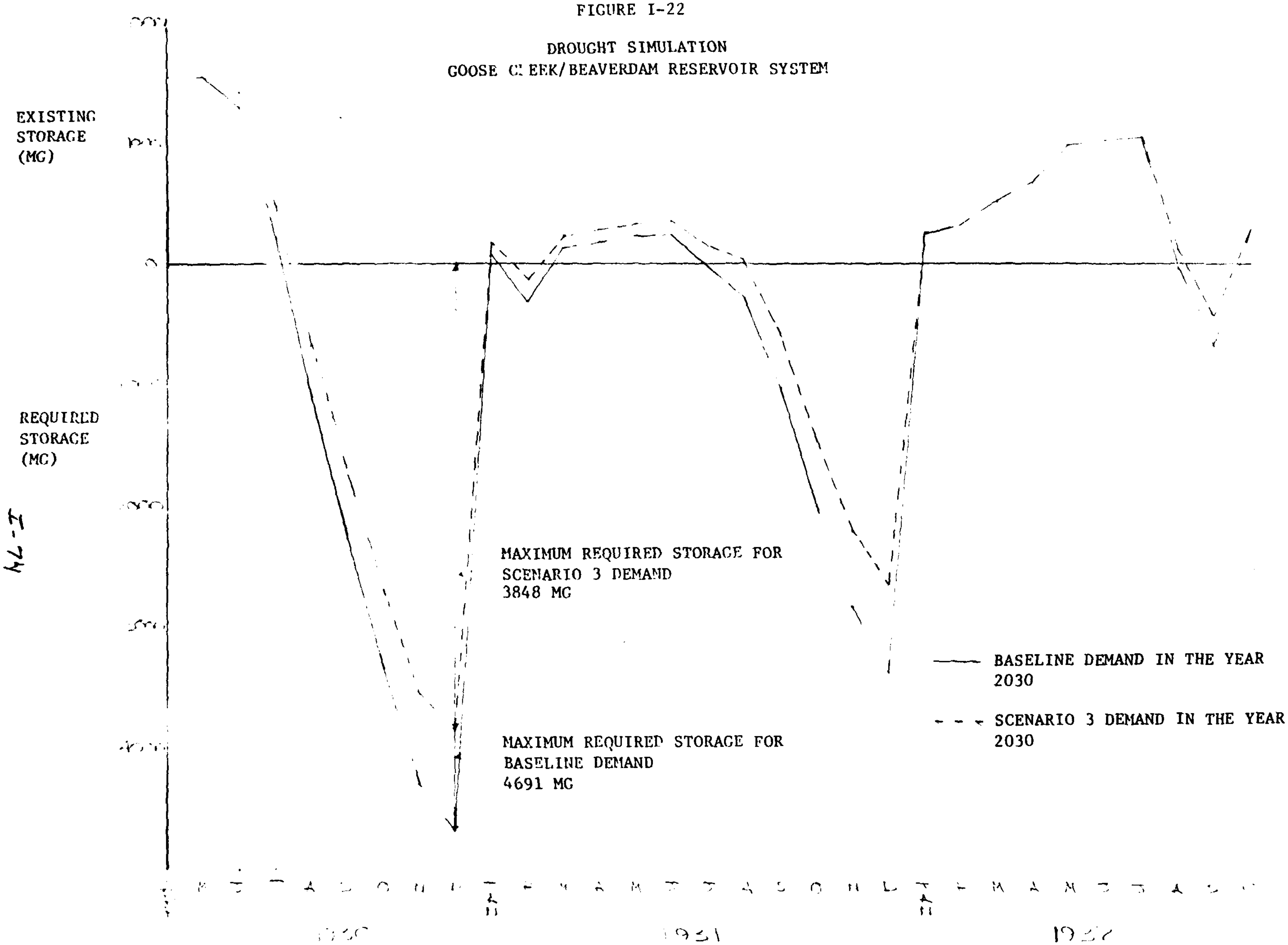
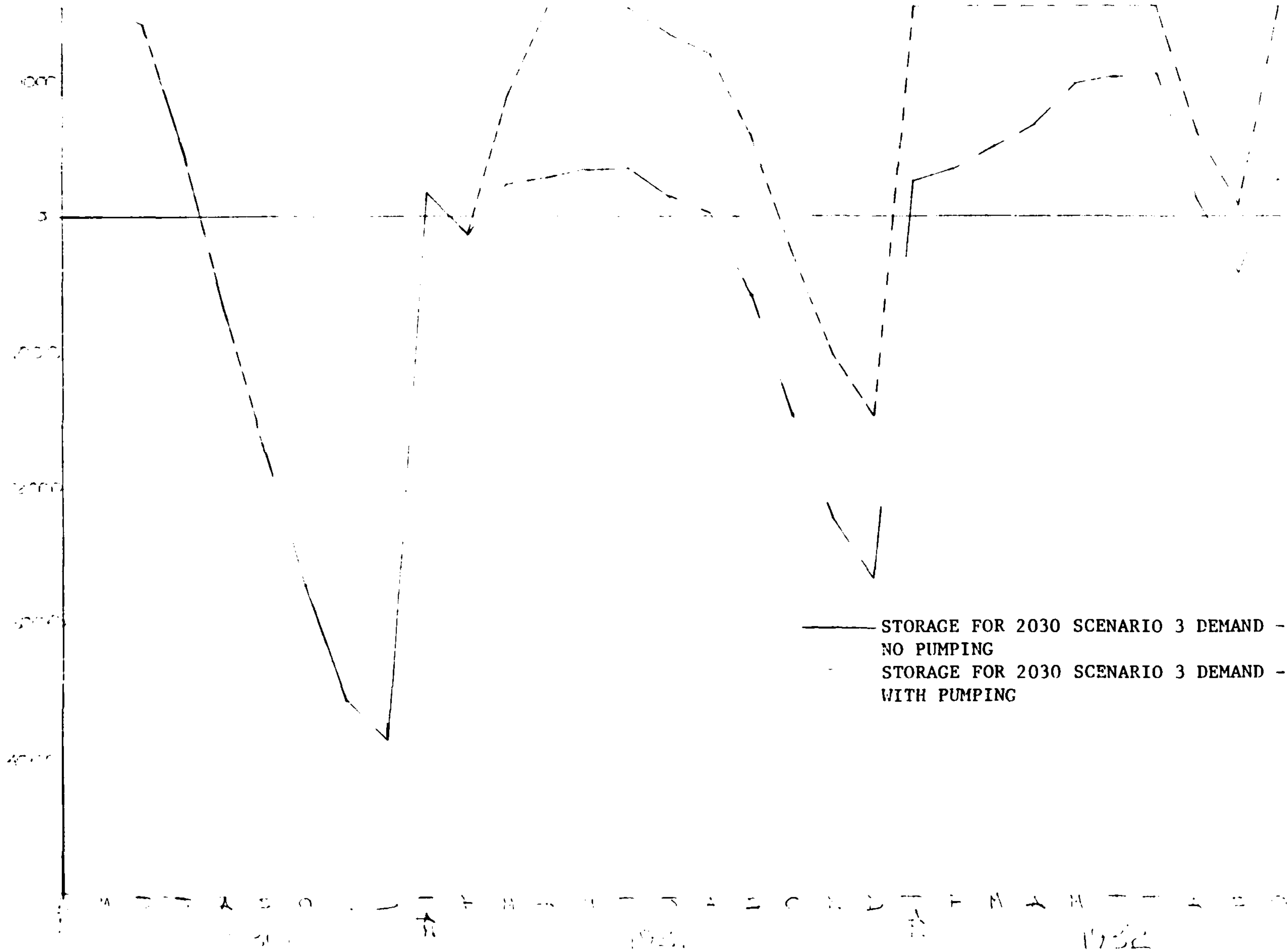


FIGURE I-23
DROUGHT SIMULATION
GOOSE CREEK - BEAVERDAM PUMPOVER

EXISTING
STORAGE
(MG)

REQUIRED
STORAGE
(MG)



PRIMARY ALTERNATIVES

The two major water supply approaches which have application to virtually all of the service areas in question are groundwater and reservoir storage. To complement these additional sources, additional water treatment plant capacity would be required. Although some of these facilities would vary from system to system, the basic design parameters would be identical for all. A range of size and cost data is provided for each of these facilities to enable local planners to compare the cost of development in their own areas considering their particular needs. The range of demand at which these alternatives were developed is sufficiently broad (10-50 mgd) to allow planners to compare the cost of development at a small scale versus that scale which might be required at increasing levels of regionalization.

Design and Cost of Primary Alternatives

The design and cost for each primary alternative was developed independently. The costs for the various components were estimated using the Methodology for Area-wide Planning Studies (MAPS) computer program developed by the U.S. Army Corps of Engineers' Waterways Experiment Station. It is a generalized planning tool for evaluating water resource alternatives. As such, it provides preliminary design and cost estimates for comparison purposes. These costs should not be utilized as future project estimates, because they do not reflect detailed project planning and site considerations.

The costs in the MAPS program account for many of the independent variables that normally impact on costs. Consequently, the results are usually more accurate than generalized cost curves available in literature, which are a function of only one or two variables. The MAPS program takes user-specified, engineering design data and applies several cost functions to determine various construction costs and operation and maintenance costs. Itemized construction, total construction, overhead, land, total capital, amortized capital, operation and maintenance, labor, material and supply, power, total operation and maintenance, and average annual costs are provided by the program. All costs are calculated by the program except for the land cost which is input directly by the user. The costs are based on a set of economic data (user-specified). For this analysis, the costs reflect October 1981 economic conditions.

The economic data assumed for this study include an Engineering-News Records (ENR) Construction Cost Index of 3610 and a Small City Conventional Treatment (SCCT) Index of 200. The SCCT index reflects municipal watewater treatment facility costs for 5-mgd plants at various locations in the United States. For the outlying areas, indices for Cumberland, Maryland, Harrisburg, Pennsylvania, and the entire United States were considered, and the value of 200 selected. In addition to these two indices, a power cost of 4.0 cents per kilowatt-hour and an O&M labor wage of $7.00 per hour was assumed.

For the amortization calculations, an interest rate of 10 percent was assumed. This interest rates represents on an average the rate at which the affected localities would likely enter the bond market to finance major capital improvements. Although this rate is probably below the rates currently available, it was felt that it represented a good estimate for planning purposes. A 50-year payback period was assumed for all amortizations.

Reservoirs

For the analysis, site specific data from the proposed Cedar Run Reservoir (developed by GKY and Associates for the MWA Water Supply Study, July 1978 and based on local report data) was utilized as base information in the MAPS program. This site was chosen for a number of reasons. Firstly, it exhibited characteristics typical of other potential site locations in both Prince William and Loudoun counties. Secondly, it represented a realistic upper limit of the storage capacity that could meet any one service area's or sub-area's needs. A series of costs and designs for smaller reservoirs could then be developed for the Cedar Run site in the form of the generalized cost curve which could be applied to other potential locations.

An area capacity curve and a cross section of the proposed Cedar Run damsite served as initial input data. An earth embankment dam with a concrete lined spillway was assumed for this analysis. The crest of the dam was set at 30 feet. For the spillway design, the design flow of 32400 cfs which was developed for the Cedar Run site was assumed. An outlet for 20 mgd (30 cfs) was sized by MAPS based on a maximum daily draft.

The dams were composed of 30 percent impervious material and included a 2-foot deep foundation trench the width of the crest. The 2-foot depth represents the depth to solid bedrock below the weathered bedrock. The slopes on both sides of the dam were 1 (vertical) to 2.5 (horizontal). Riprap material was provided on the upsteam face of the dam to a depth of 30 inches. An average of five feet of soil would need to be stripped from the surface for the dam foundation. These basic design assumptions are depicted in the typical dam cross-section and front view in Figure I-24.

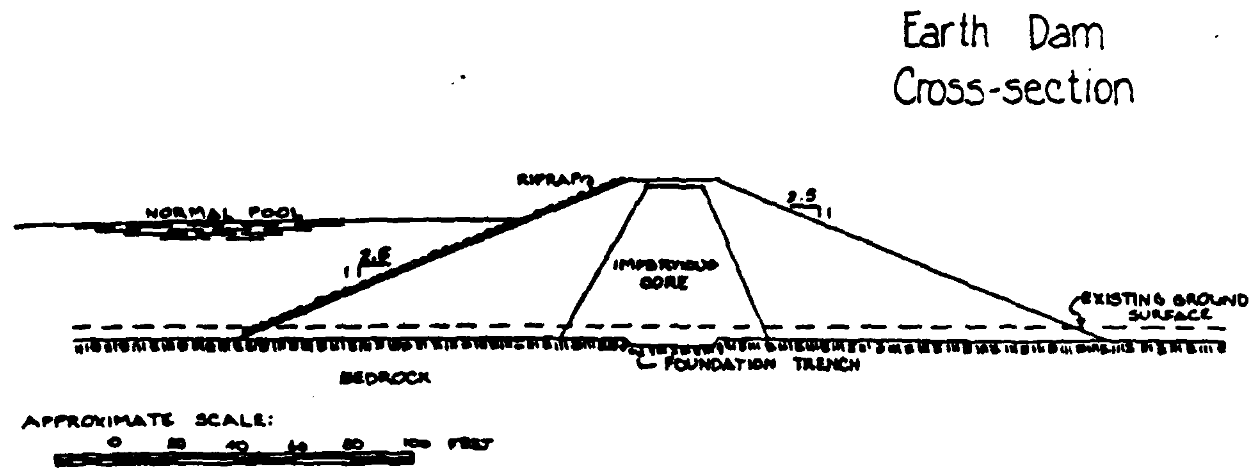
Associated with the construction of the dam would be the purchase of the reservoir inundated land. The cost of these items was also estimated. All land inundated by the reservoir at dam crest was assumed to be purchased outright at a cost of $4000 per acre. This value is an estimate of the undeveloped land cost. Much of this land would be higher than the normal reservoir surface and would remain in its natural state. The land normally inundated by the reservoir would have to be cleared of existing trees and brush. However, some brush and stumps would be left near the shoreline for enhancement of the fishery. Therefore, the cleared land was set at 95 percent of the normal inundated surface area. Because the amount and type of relocations would vary considerably depending upon the site chosen, relocation costs were not included in this analysis. In this respect, additional costs would have to be evaluated on a site specific basis.

Using the aforementioned design assumptions, the MAPS program generated costs for a series of storage levels for a generalized site in the outlying areas. The resulting capital and annualized costs were plotted to give approximate storage-cost curves for this idealized site (Figure I-25, and I-26, respectively).

The curves show that a maximum size reservoir would cost approximately $22 million (this closely approximates the Prince William County estimated cost for Ceder Run). This size reservoir represents as upper limit of storage volume that would be required to meet the needs of any one service area during a prolonged (4 month) drought. Any point along the curve represents a reservoir size and corresponding cost that could match the needs of varying size communities within the outlying areas.

Figure I-24

TYPICAL DAM CROSS-SECTION
AND FRONT VIEW



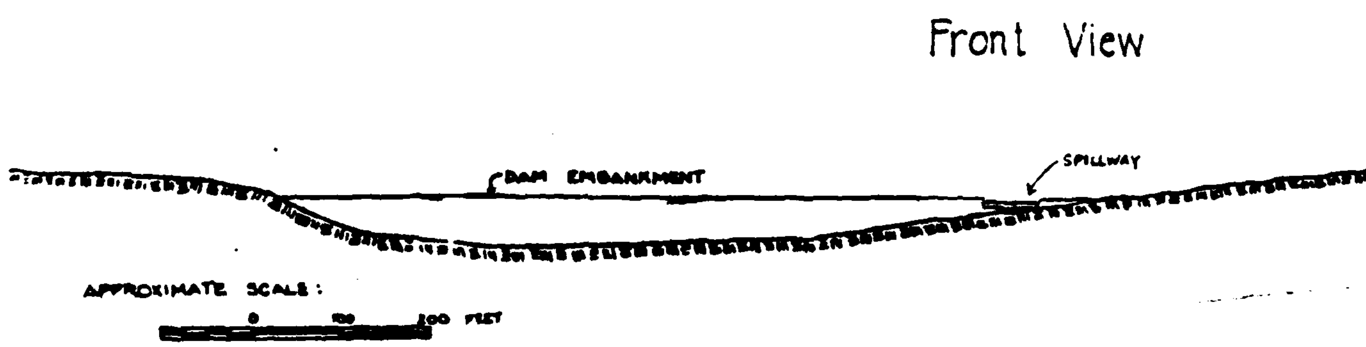


FIGURE I-25

CAPITAL COST CURVE - RESERVOIR STORAGE

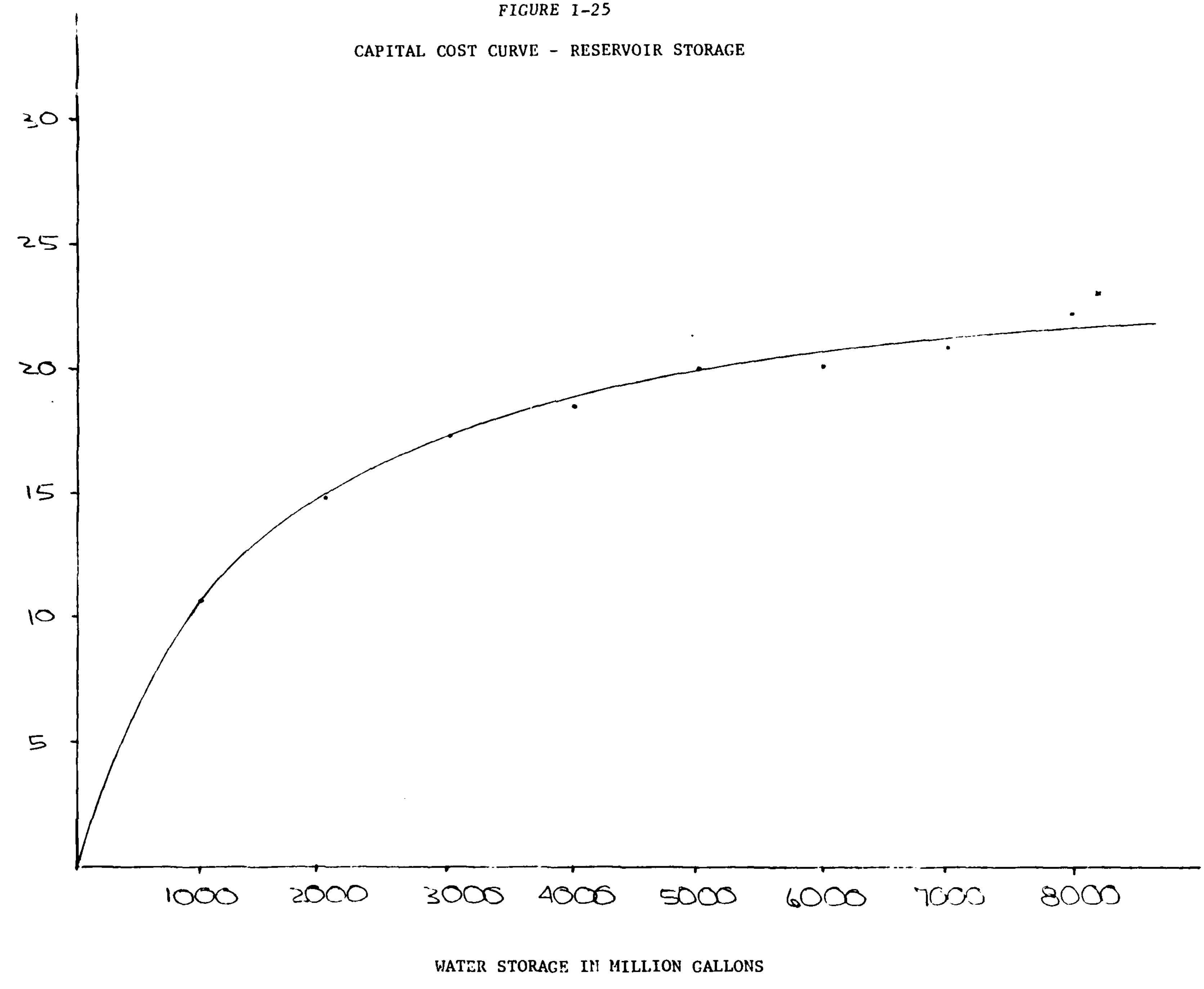
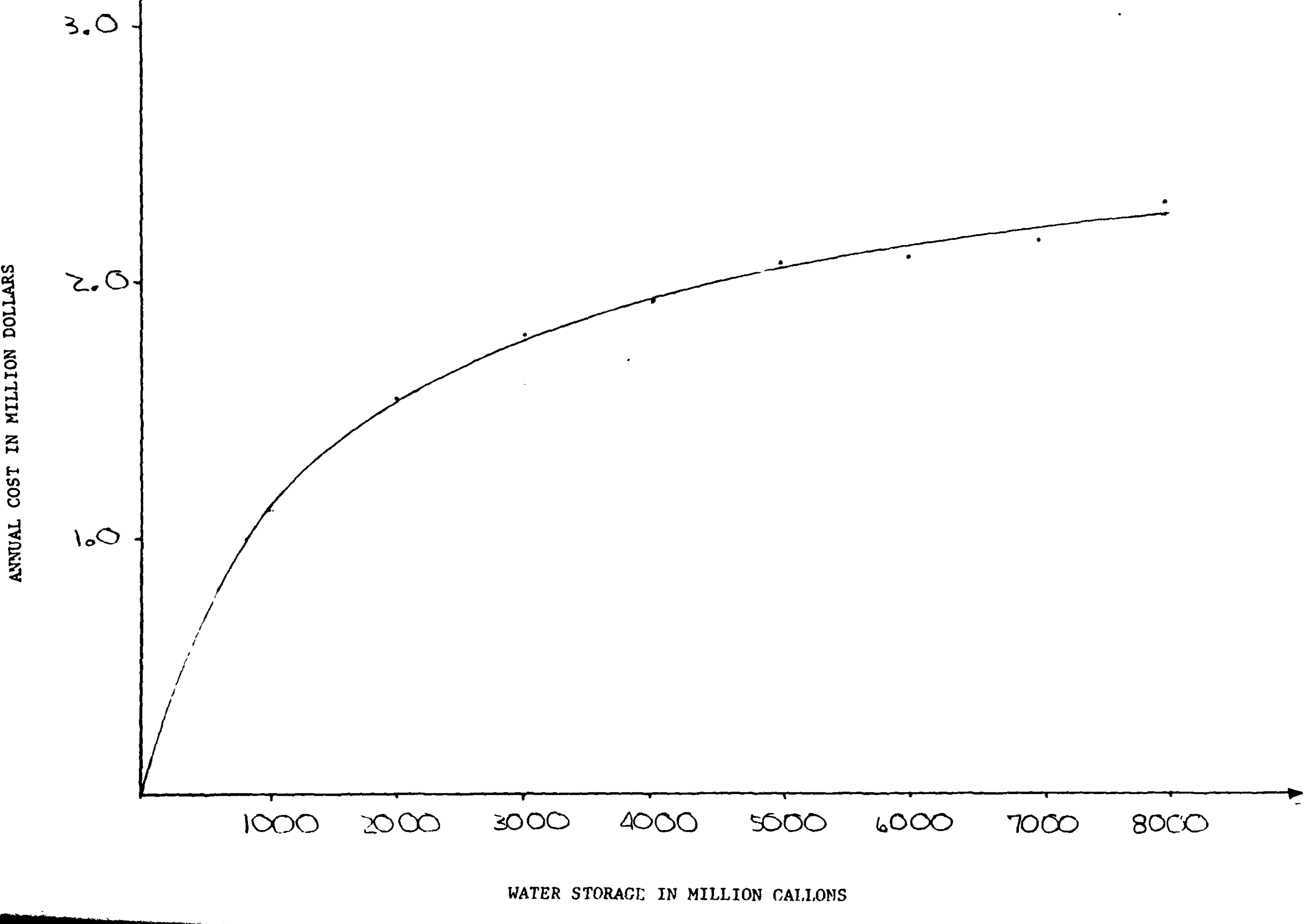


FIGURE I-26

ANNUAL COST CURVE - RESERVOIR STORAGE



Groundwater

Three broad geologic regions were considered in evaluating potential well field systems. These include the Blue Ridge, Triassic Lowland, and Coastal Plain regions (Figure I-27). These areas were differentiated on the basis of geology and the differing yield capacities which are commonly associated with wells in each region. While actual well yields are likely to differ by location within each region, for the purposes of this analysis it was assumed that conditions would be somewhat uniform and input into the MAPS program was based on average data collected for each region.

Table I-34 summarized the hydrologic input data for the three well locations which were evaluated. The data presented for the Blue Ridge area are based on information averaged from existing well data for the Towns of Hamilton and Purcellville. This area generally has the poorest potential among the three major regions for producing large and reliable volumes of water. Input data for the Triassic Lowland wellfield is based on average figures from existing well data summarized for the Trissic Lowland portion of Prince William County by Geraghty and Miller, 1978 (see Review of Planning Studies Conducted By Others). A much greater potential exists for groundwater development in this area in comparison to the Blue Ridge area where average yields are on the order of 150 gpm less than the Triassic Lowland. The data for the Coastal Plain aquifers were developed from a report prepared by the Maryland Geological Survey for Charles County, Maryland (1968) as well as from the Geraghty and Miller Report which represents information for the Cretaceous aquifer in Prince William County.

Table I-34

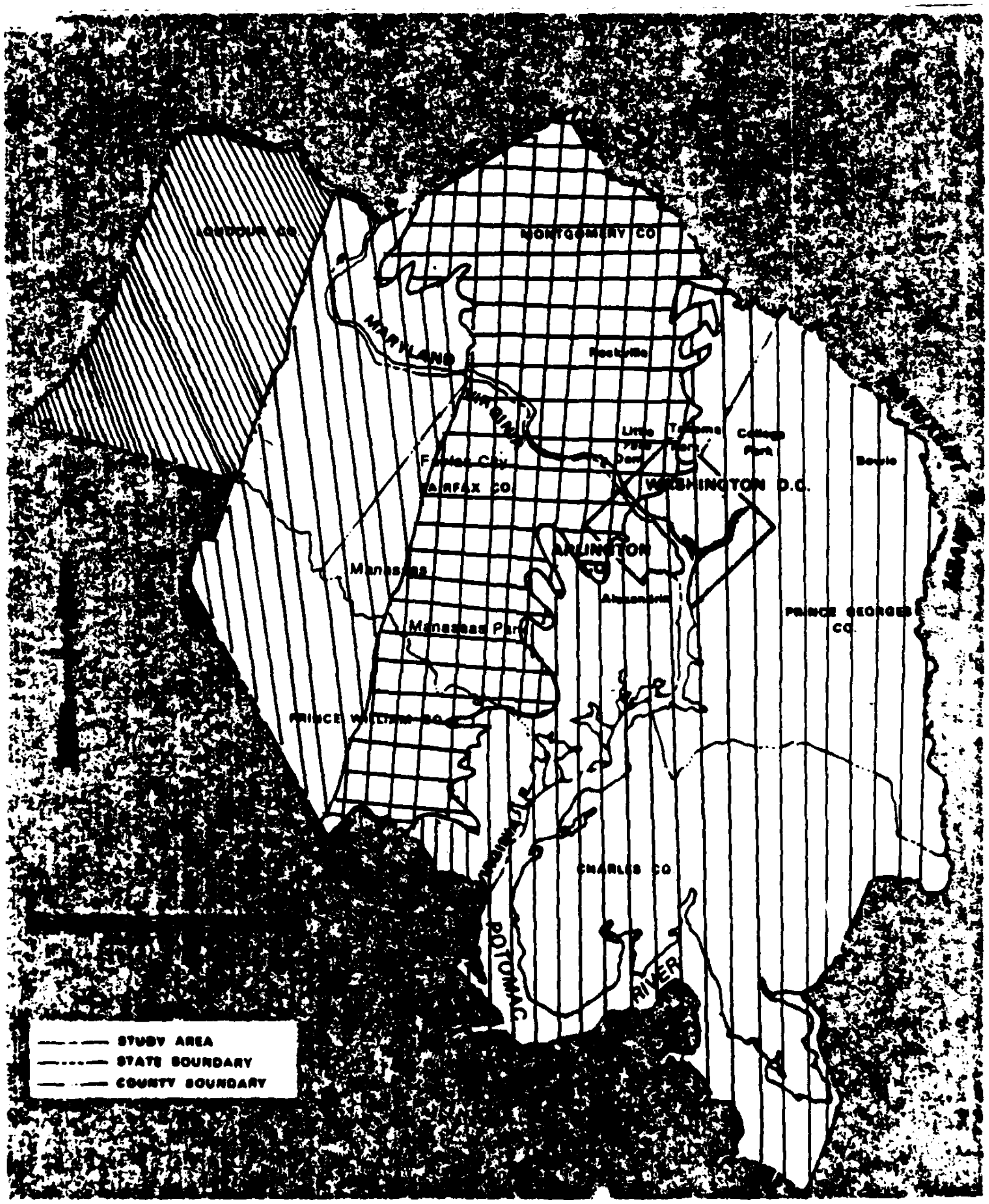
WELLFIELD HYDROLOGIC INPUT DATA

Geologic Area	Blue Ridge	Triassic Lowland	Coastal Plain
Well Depth (feet)	350	600	300
Average Well Yield in Developed System (gpm)	30	175	150
Specific Capacity (gpm per foot of drawdown)	0.8	1.5	2.0
Depth to Static Water Level (feet)	30	85	30
Bedrock Conditions	Shallow	Shallow	Unconsolidated

These groundwater data were then used as input together with other design data for the MAPS computer program for various levels of flow. The wells were assumed to be spaced 250 feet apart in a circular pattern. The number of required wells was calculated based on the previously discussed well yields. For example, a demand of 10 mgd in the Coastal Plain would require 46 wells yielding 150 gpm per well. The radius of such a well field was calculated from the definition of a circle's circumference. The radius was

FIGURE I-27

MAJOR GEOLOGIC REGIONS FOR GROUNDWATER DEVELOPMENT



Piedmont Province

Triassic Lowland

Blue Ridge Complex

Coastal Plain

equal to 250 times the number of wells divided by 2 pi. In the example, the Coastal Plain well field would have a radius of 1800 feet or 0.35 miles. The area requirements were calculated using this radius and the formula for a circle's area. An additional 10 percent of the area was included for facilities and a protective buffer zone.

The wells were assumed to be connected to a central collection point within the well field. From there, a larger force main would be required to convey the water to a distribution system. For the individual well fields, 200 feet of pressure was assumed at the central point. Of this 200 feet of head, 150 feet was required for residual pressure in the connecting pipe. Vertical turbine pumps with an efficiency of 80 percent were used to provide the requisite pressure head. Test wells and some type of housing were included in the cost analysis. Drilling costs of the wells reflected the shallow bedrock or unconsolidated conditions. As for the reservoir, land costs were set at $4000/acre. Using the design data detailed above, the MAPS program calculated capital and annual costs for each of the wellfield locations. The resulting capital cost annualized cost curves for the three geologic regions are graphed in Figures I-28 through I-33.

Water Treatment Plant Expansions

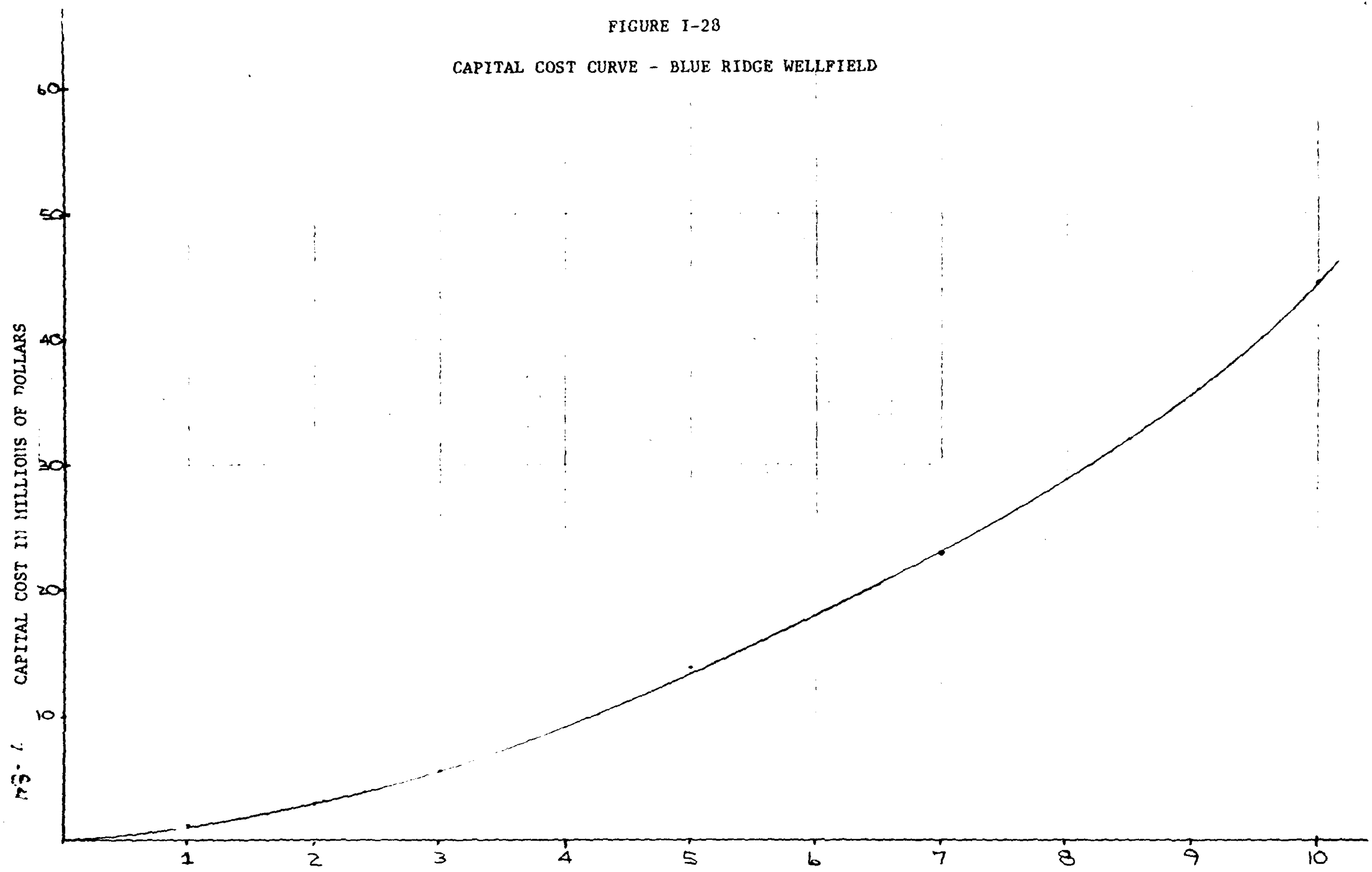
Development of additional water sources will likely require additional water treatment capacity in the outlying areas. This study investigated two levels of treatment - chlorination and full-scale filtration facilities. The groundwater supply in the study area would need the first level of treatment, while all surface sources would require the second. These assumptions are based on current water quality data in the region. Lack of proper land management or further degradation of the groundwater source would require a reevaluation of this assumption.

The cost analysis of the chlorination treatment assumed cylinder storage of the chlorine gas and a dosage of 50 lbs of chlorine per 1 million gallons of water. This treatment dosage is equivalent to 6.0 mg/l which should be more than sufficient to destroy all bacteria and leave an adequate residual. The land for the chlorination facility was considered already purchased as part of the source development plan (i.e., the facility would be located at the wellfield) and therefore, it was not included in the costing of the chlorination treatment component. Using this design data, the MAPS program generated capital and annual costs. The capital and annual costs for chlorination treatment are plotted in Figure I-34 and I-35, respectively.

The filtration facilities were similarly designed. The major processes in this treatment component were clarification flocculation, rapid sand filtration, powdered carbon, and chlorination. These processes are consistent with surface water treatment plants in the study area (Fairfax City as example) vicinity. A rectangular clarifier with an overflow rate of 550 gpd/square foot was the first treatment level. For the flocculation process, a liquid alum feed of 10 lbs/million gallon was assumed. The basin detention time and rapid mix detention time were set at 30 minutes and 1 minute, respectively. The rapid sand filter was designed as a gravity-type filter with a loading rate of 5 gpm per square foot and a backwash pumping rate of 5,000 gpm. Surface washes and filter backwashes were assumed to occur twice a day. The powdered activated carbon process, which is used to remove organics from the treated water, had a carbon dose rate of 10 lbs/million gallon. The chlorination process was the same as described in the earlier treatment level. As with the simple chlorination plant assumptions, land costs for the plant were considered to be part of the cost for source development. The cost for the filtration facilities are reflected in the capital and annualized cost curves in Figures I-36 and I-37,

FIGURE I-28

CAPITAL COST CURVE - BLUE RIDGE WELLFIELD



AVERAGE FLOW IN MILLION GALLONS PER DAY
WELLFIELD #1
(BLUE RIDGE PROVINCE)

FIGURE I-29

ANNUAL COST CURVE - BLUE RIDGE WELLFIELD

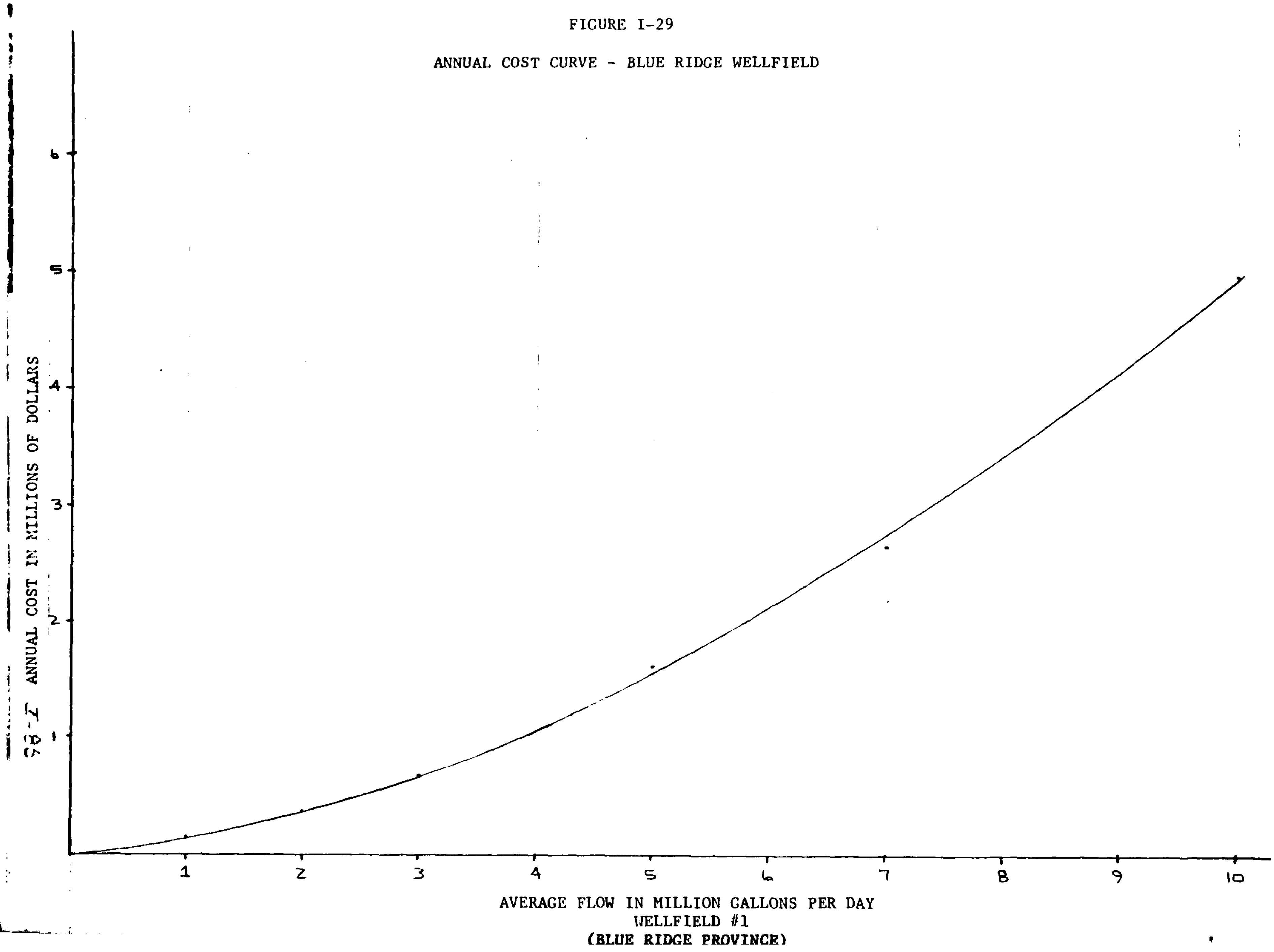
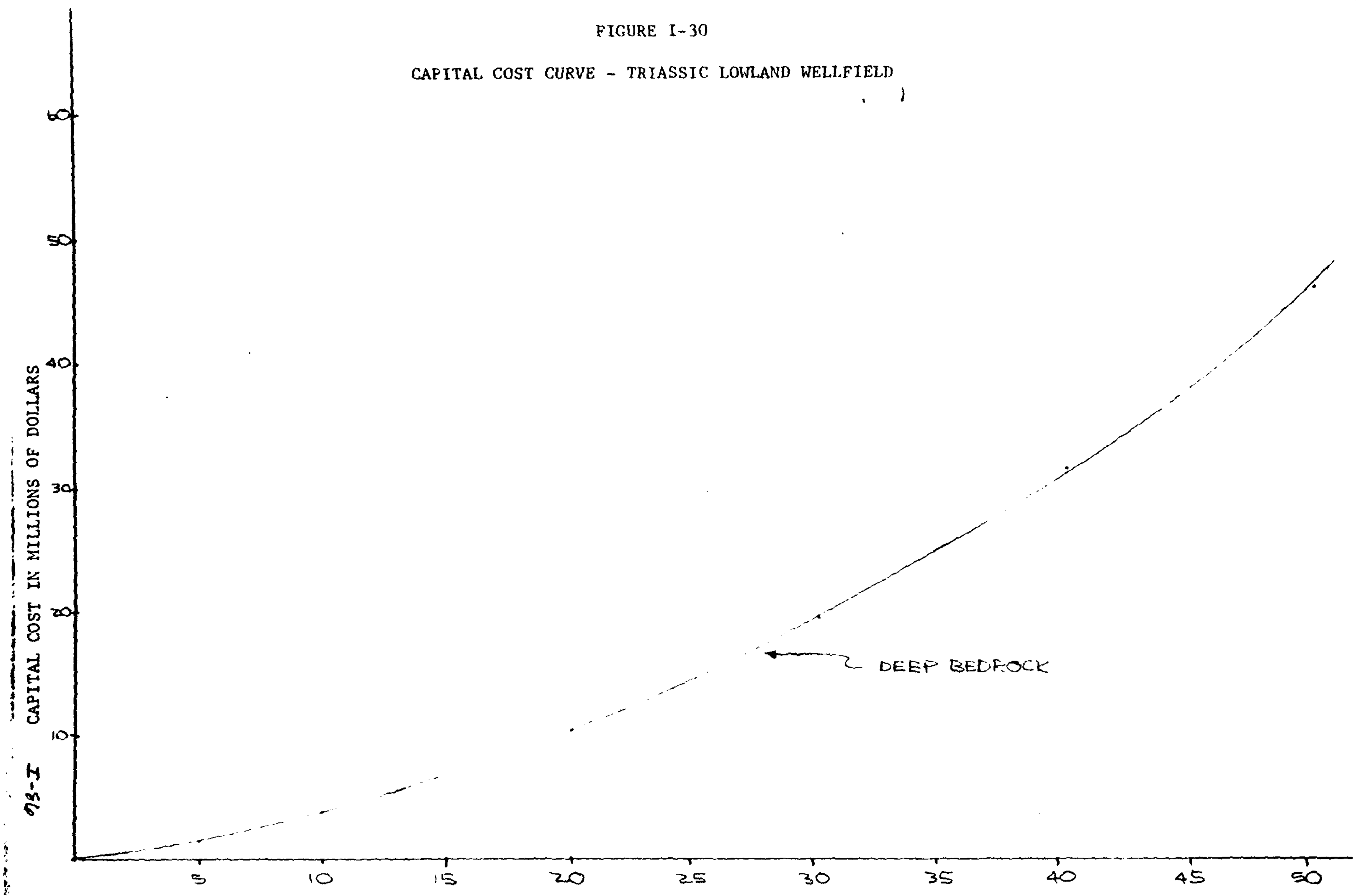


FIGURE I-30

CAPITAL COST CURVE - TRIASSIC LOWLAND WELLFIELD



AVERAGE FLOW IN MILLION GALLONS PER DAY
WELLFIELD #2
(TRIASSIC LOWLAND)

AD-A134 162 METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY 2/2
APPENDIX I OUTLYING SERVICE AREAS(U) CORPS OF ENGINEERS
BALTIMORE MD BALTIMORE DISTRICT SEP 83 MWA-83-P-APP-I

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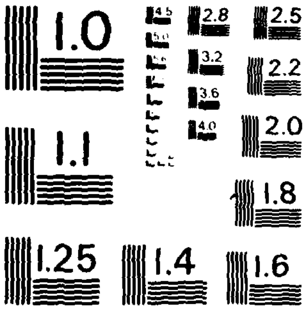
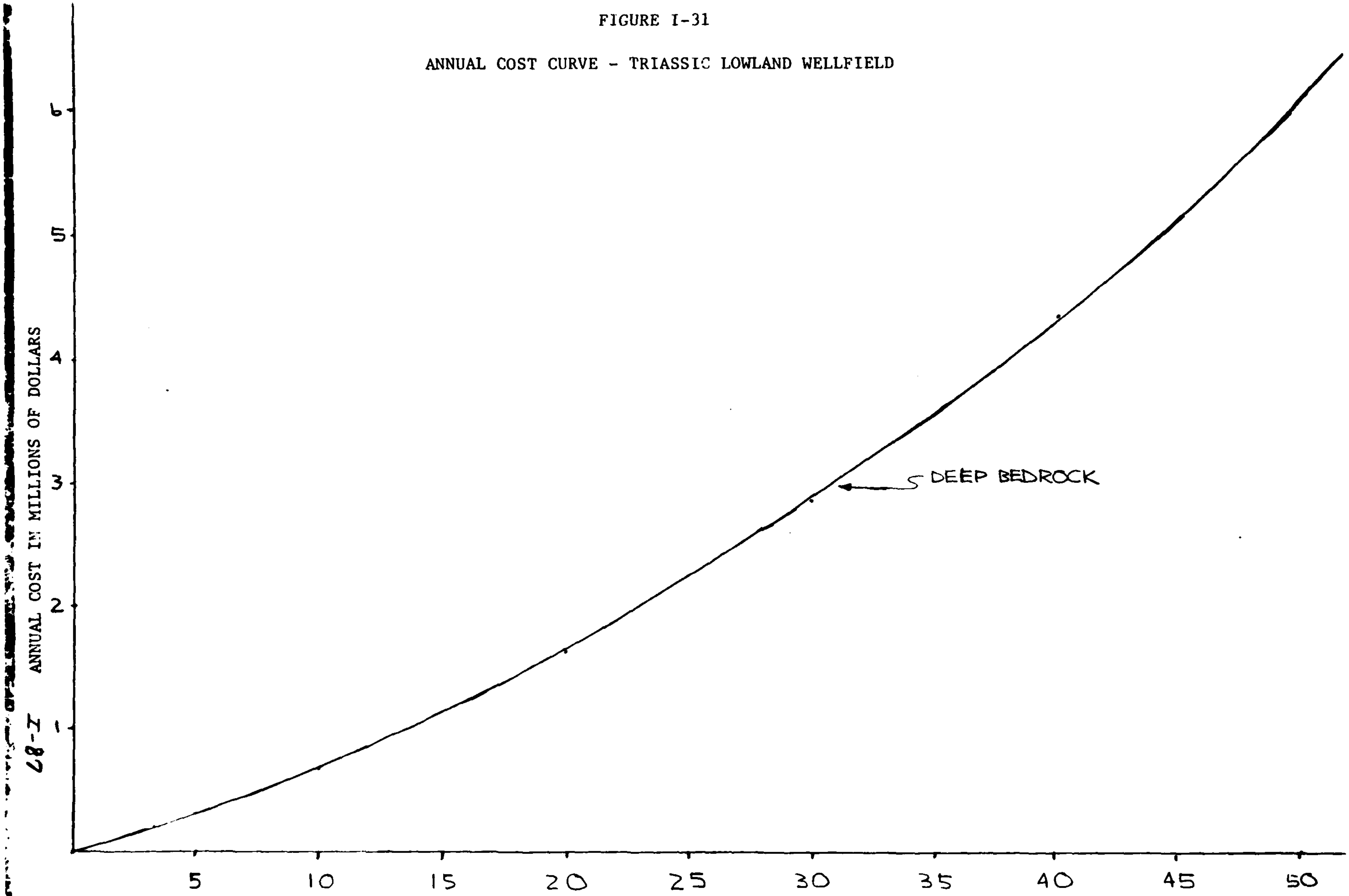


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FIGURE I-31

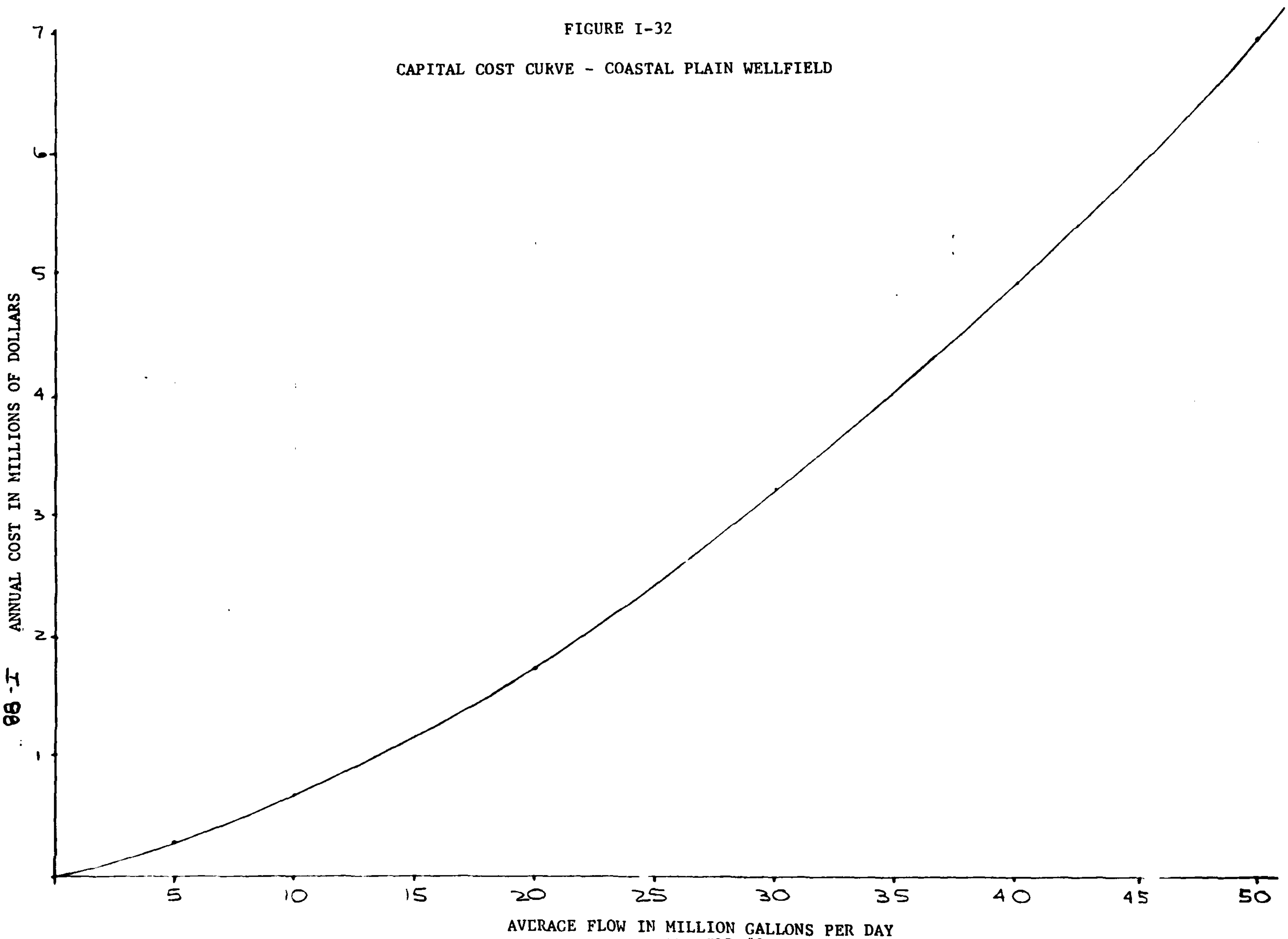
ANNUAL COST CURVE - TRIASSIC LOWLAND WELLFIELD



AVERAGE FLOW IN MILLION GALLONS PER DAY
WELLFIELD #2
(TRIASSIC LOWLAND)

FIGURE I-32

CAPITAL COST CURVE - COASTAL PLAIN WELLFIELD



WELLFIELD #3

(COASTAL PLAIN)

FIGURE I-33

ANNUAL COST CURVE - COASTAL PLAIN WELLFIELD

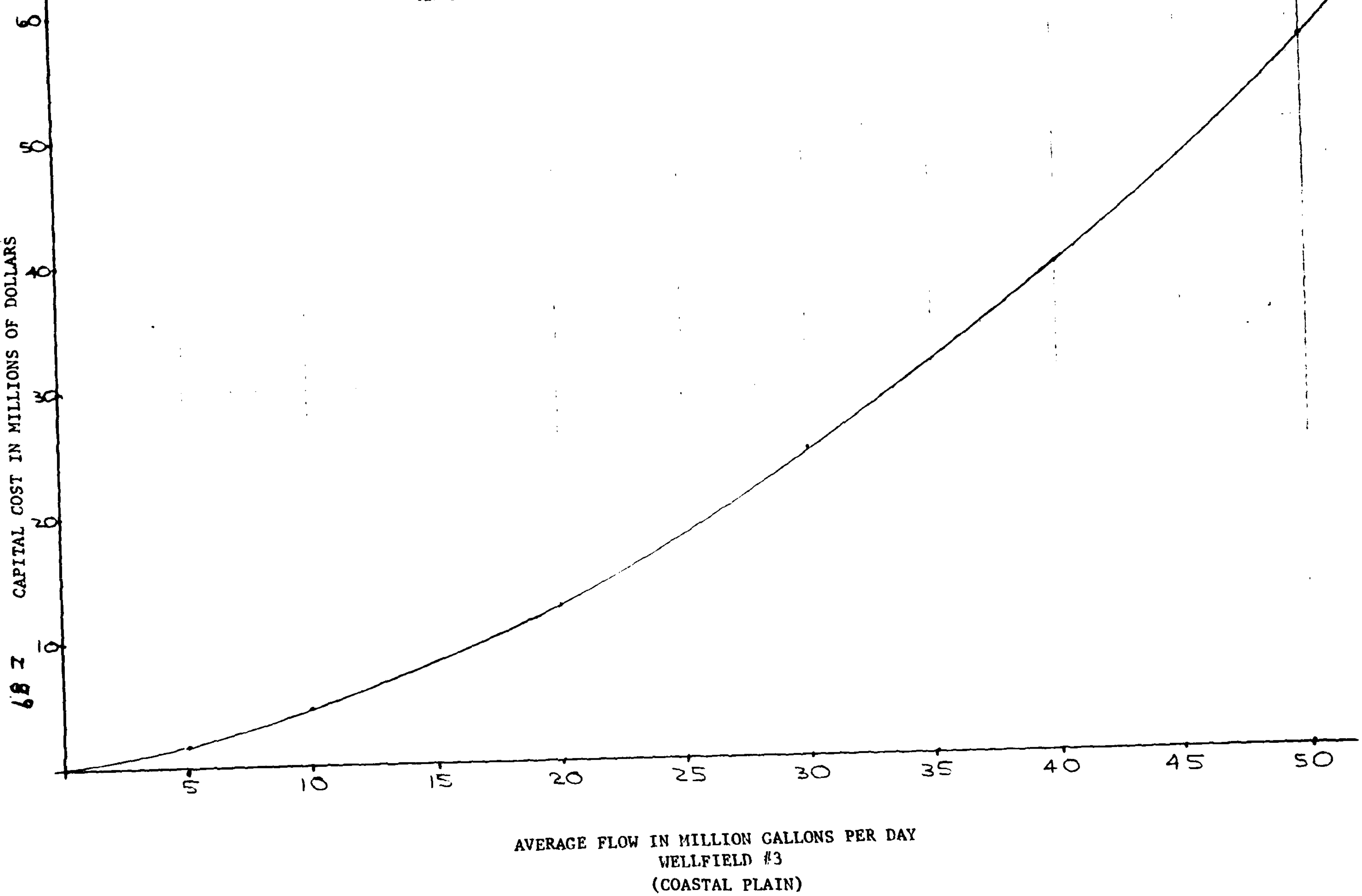
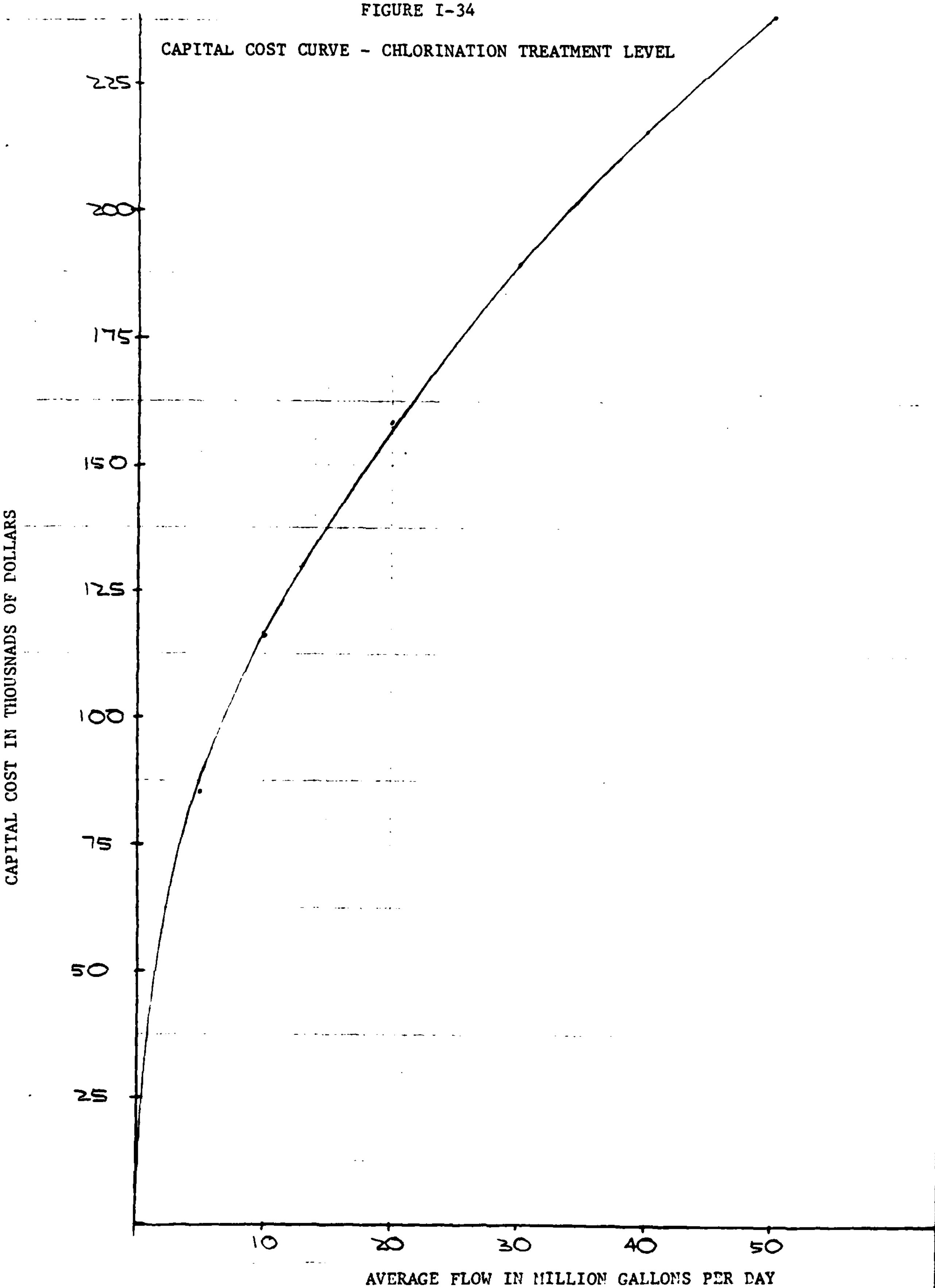


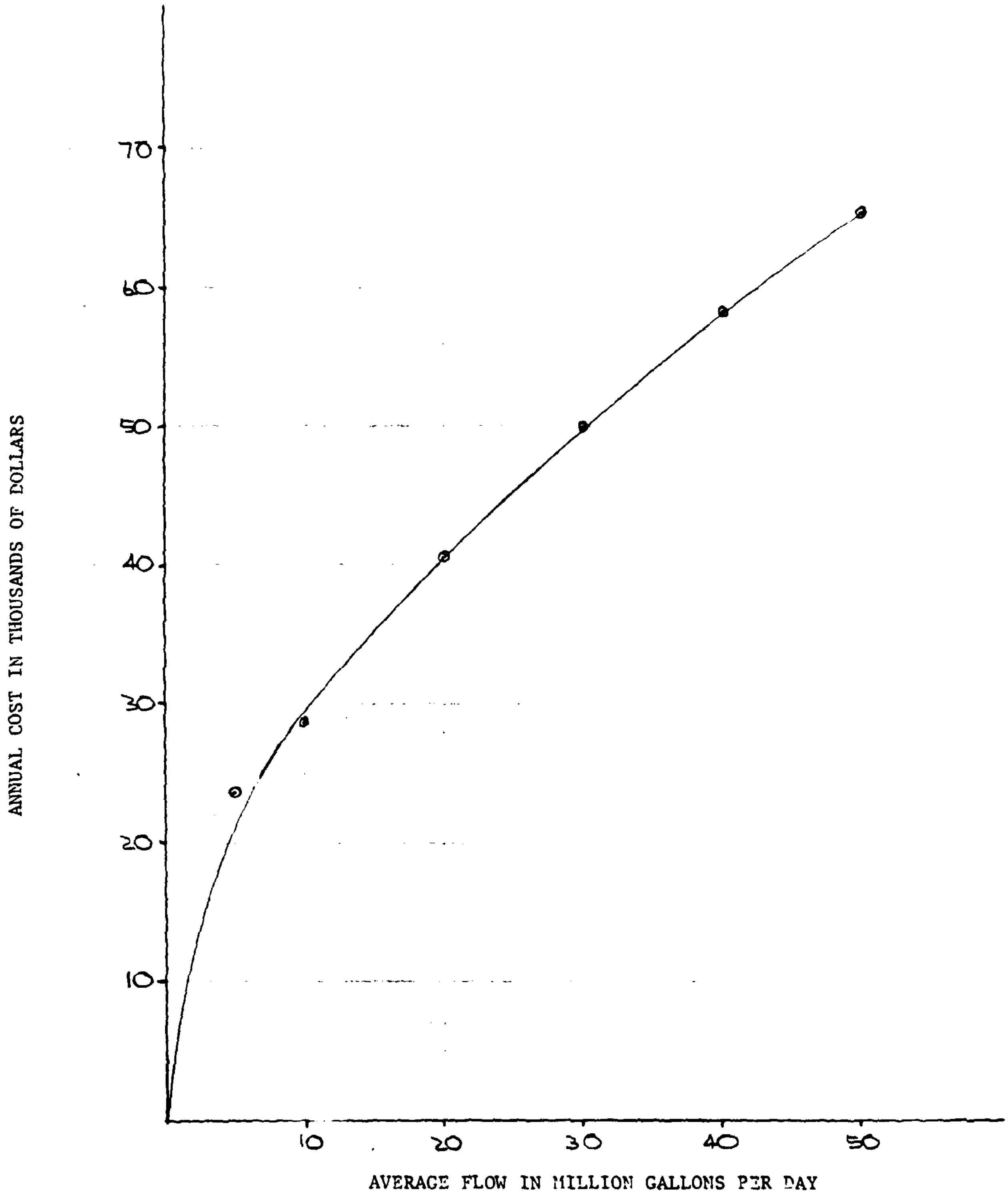
FIGURE I-34



TREATMENT PLANT #1 — CHLORINATION

FIGURE I-35

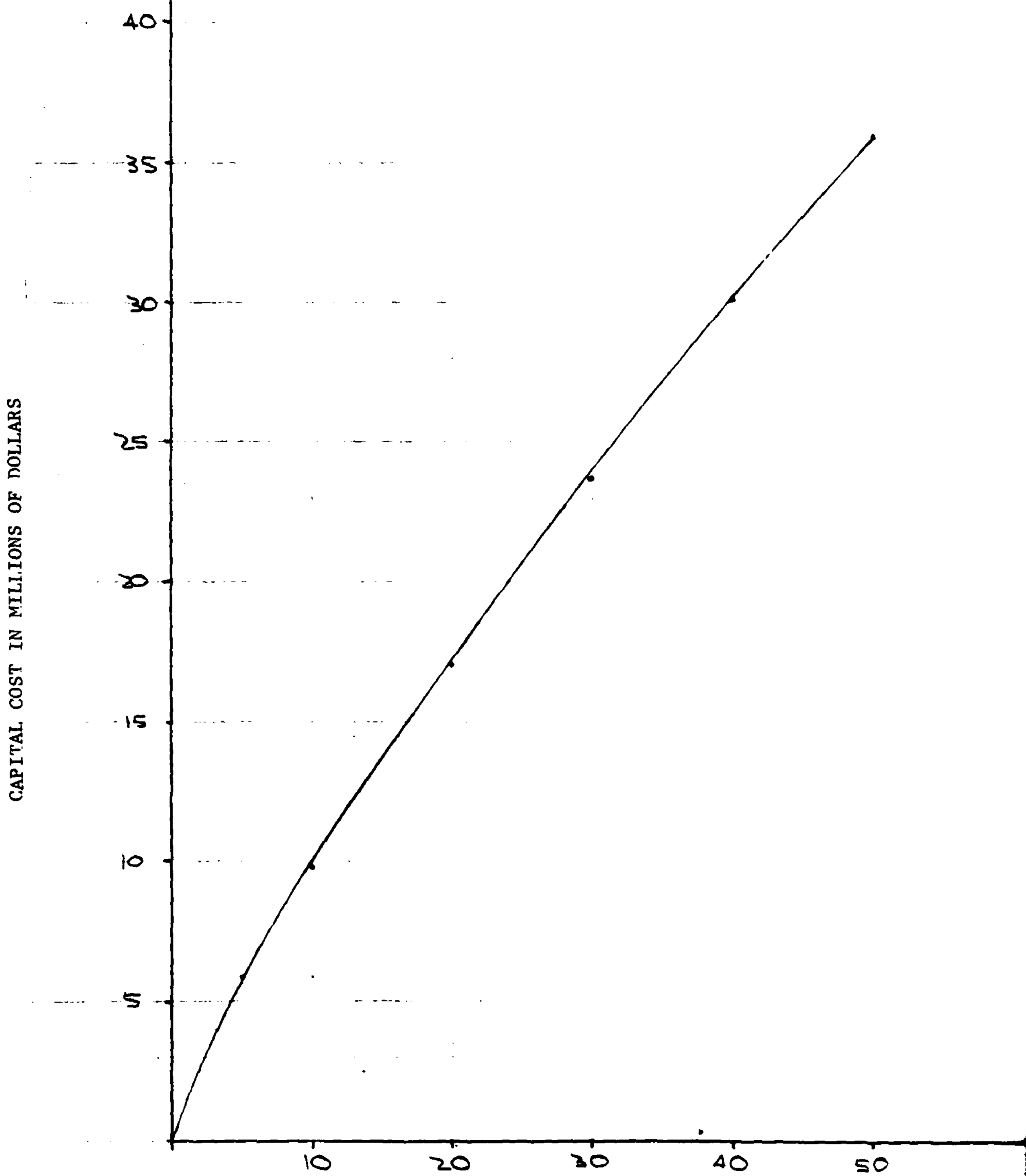
ANNUAL COST CURVE - CHLORINATION TREATMENT LEVEL



TREATMENT PLANT #1 - CHLORINATION

FIGURE I-36

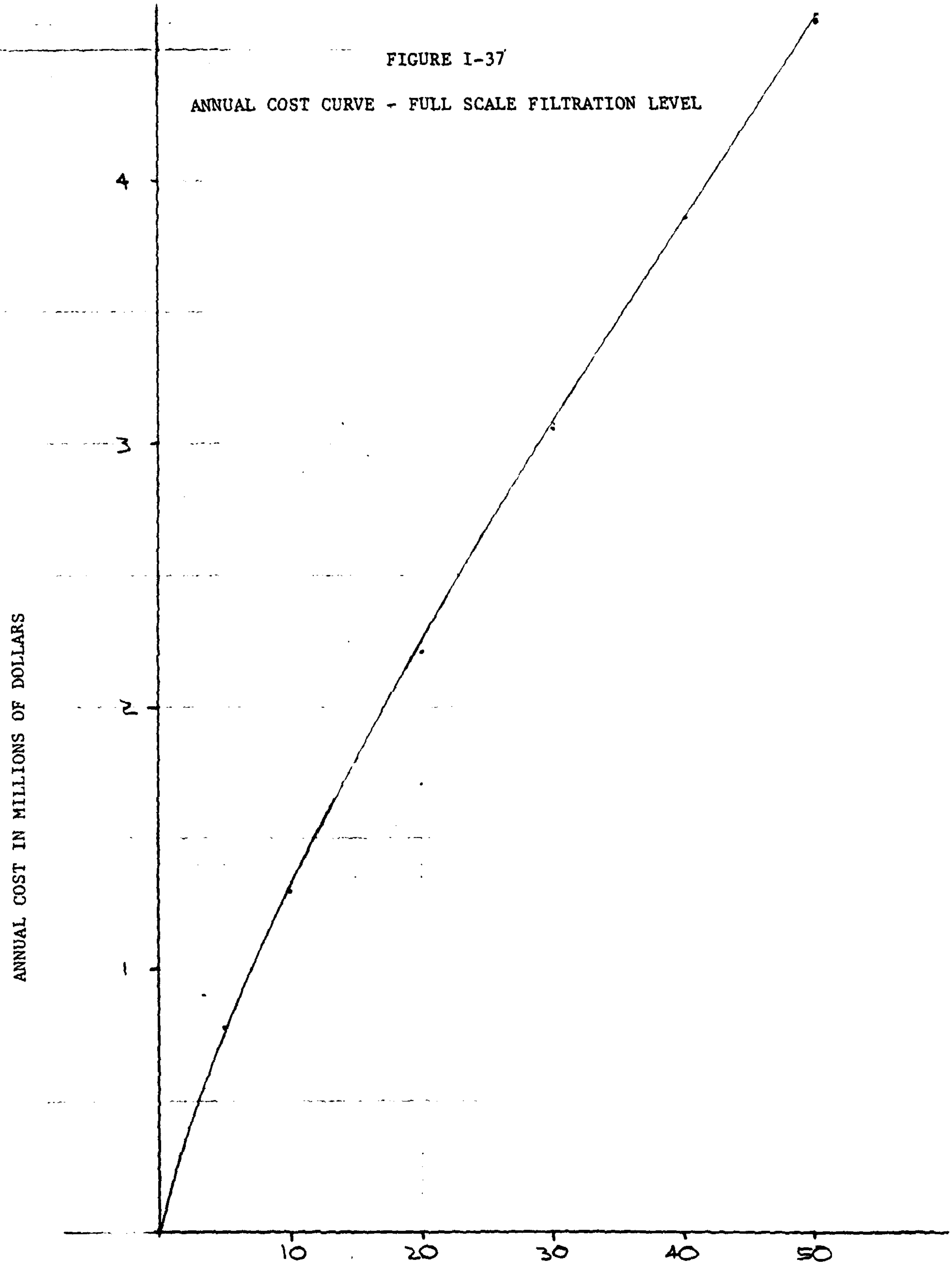
CAPITAL COST CURVE - FULL SCALE FILTRATION LEVEL



AVERAGE FLOW IN MILLION GALLONS PER DAY
TREATMENT PLANT #2 - FULL SCALE FILTRATION

FIGURE I-37

ANNUAL COST CURVE - FULL SCALE FILTRATION LEVEL



AVERAGE FLOW IN MILLION GALLONS PER DAY
TREATMENT PLANT #2 - FULL SCALE FILTRATION

respectively. These figures demonstrate the significant difference in treatment costs between simple chlorination and full scale filtration by several orders of magnitude. For example at 50 mgd, capital costs for a full scale filtration plant approaches $37 million whereas similar capacity at a chlorination only plant would approach $235,000.

Impacts of Primary Atlernatives

In terms of environmental and social impacts any reservoir constructed in the outlying service areas could have major impacts that would of course, increase with the size of the reservoir constructed. The construction of a man-made lake would inundate the existing stream valley and adjacent farmland and forest wildlife habitat. The dam could block fish movement within the stream; and the reservoir would degrade the existing stream fishery habitat by lowering stream velocities, and consequently, increasing sediment deposition. The resulting habitat changes would see an increase in the more tolerant species of animal and plant life, while less adaptable forms of life would decline. The stream ecosystem would be replaced by a lake ecosystem with a potentially different selection and distribution of wildlife species. Drawdown of the reservoir for water supply use could cause adverse impacts to the lake environment, depending on the magnitude, timing, and frequency of reservior drawdowns.

In terms of land use, both reservoir and groundwater alternatives would have significant impacts. The reservoirs would inundate, depending on size, hundreds of acres of forest and agricultural land in most cases. In addition, the land surrounding the reservoirs would be subject to intermittent flooding. For the larger groundwater schemes, large parcels of land would be required for well field development. The land use of these sites would be restricted. In addition, monitoring and management programs for lands adjacent to the reservoir and groundwater facitities would be needed to insure adequate water quality for water supply purposes.

The social impacts of the primary water supply alternatives would be diverse and numerous. One of the most significant positive impacts would be the assurance of an adequate, safe water supply. The reservoir alternatives offer some potential for restricted recreational opportunities, within the confines of the water supply use. On the other hand, the reservoir alternatives would probably require the relocation of residences depending upon site which could negatively affect those residents. Construction of the water supply facilities would cause temporary traffic disruptions; on the other hand, it would provide some employment opportunities. The well fields which involve large withdrawals could cause drawdown problems in adjacent wells. The social impact of the drawdown would depend on whether the public system was extended for all of the residents within the wellfield's area of influence.

From an institutional view point, any alternative which would serve individual demand centers would most likely be easier to implement since they would not rely on a high degree of regional cooperation. This approach however, would reduce the economy of scale achievable with reservoirs as demonstrated in Figure I-25.

In terms of reliability, reservoirs would generally afford greater ability to meet demands; however, this would vary depending on the safe yield design of any system developed. The reliability of goundwater as a dependable source would tend to decrease with increasing the size of a wellfield. Costs would also tend to increase dramatically for land.

Water treatment plants would be anticipated to create very minor site specific impacts at the construction site.

SECONDARY ALTERNATIVES

Three additional alternatives were reviewed for their potential to supplement water supplies in the outlying areas. These include wastewater reclamation, use of the Potomac estuary, and pumpover schemes from the Potomac River.

Wastewater Reclamation

Wastewater reclamation was reviewed as a water supply measure for the entire MWA in Appendix G, Non-Structural Studies, of this report. The reader is referred to this Appendix for a more detailed discussion of the types of reclamation strategies considered and their potential application to MWA. Land application and methods for wastewater reuse were the primary wastewater reclamation measures considered as part of the review and both have some, although a limited, application for the outlying service areas. Since the information in Appendix G was developed at a less than survey scope level, a direct evaluation of their potential in individual communities in the outlying areas was not possible. The general conclusions presented in Appendix G can for the most part be extended to the outlying areas. The conclusions pertinent to the outlying areas are summarized below:

1. Land application would have limited public acceptance as a method to supplement potable water supply. Efforts to use this method on a small scale solely for wastewater renovation have been met with consistent opposition.

2. Although land application might be useful on a limited basis to produce water for non-potable uses, these are considered minor (even in the outlying areas) and would not appreciably change the future.

3. Land application for water supply is land intensive, seasonal, and limited by specific topographic requirements. This makes it expensive, unreliable and limited in geographic application.

4. Land application or wastewater reuse could have some utility in the outlying areas in a groundwater recharge mode. Generally speaking however, health regulations require a minimum of high quality secondary treatment and often more advanced wastewater treatment to assure groundwater supplies are not contaminated. Since groundwater represents the major water supply source in the outlying areas, the potential health risk could be enormous.

Use of the Potomac Estuary

One of the alternatives which has long been advocated to alleviate projected water supply deficits in the MWA is use of the Potomac Estuary. However, because of its uncertain composition, complex biological and chemical interactions, unknown environmental impacts of freshwater withdrawals on salinity regime, and other aquatic and biotic uncertainties, the use of estuary water was always considered questionable. A

Pilot Potomac Estuary Treatment Plant constructed at the District of Columbia Blue Plains Water Pollution Control Plant and currently operated in a testing mode has provided some valuable information regarding the treatability and potability of Potomac estuary water under varying conditions (see Appendix F, Long Range Structural Alternatives for a complete discussion of the testing program).

With respect to the outlying areas, the potential for pumping treated water from an expanded (full scale) Potomac Estuary Treatment Plant located in the District of Columbia would be limited due to the great distances to these demand centers. The consideration given to the present Pilot Plant was based primarily on its potential to serve the urban core of the MWA. The only reasonable alternate locations of an estuary plant for the outlying areas would be along the Potomac shoreline in either Charles County, Maryland or Prince William County, Virginia. Since these locations are at least 15-20 miles further south on the Potomac Estuary where the salinity, tidal, and other chemical and physical characteristies of the estuary are quite different than at the current Pilot Plant location, it would be unreasonable to extend any of the conclusions from the Pilot Plant study to these areas. It is certain that salinity problems would be much greater in these areas than at location upstream. It can generally be concluded that if an estuary plant were technically feasible in either Prince William County or Charles County, it would not benefit from the economies of scale possible as could a large expanded facility (such as the PEWTP in Washington) because of the relatively small demand levels in this region. Furthermore, there are likely to be difficulties revolving around public acceptability of using the estuary.

Potomac River Pumpovers

A third possible method for augmenting supplies in the outlying areas is by pumping water from the Potomac River. As noted earlier, the Town of Leesburg, Virginia which is located in close proximity to the Potomac, recently completed construction of an intake, treatment plant and conveyance system which is now operational. No other communities in the outlying areas currently use the Potomac River as a source and little if any planning has been done which considers this possibility. The Black and Veatch report discussed in an earlier section did develop data for a series of high flow skimming reservoirs in Loudoun and Fairfax counties which would require raw water pipelines. These facilities were conceived and designed however, independent of the needs of other outlying communities.

The freshwater portion of the Potomac River represents the most likely raw water source for a pumpover and as such would be most applicable to communities in northern Loudoun County or the Fairfax City Service Area. The feasibility of this alternative for individual small communities in northern Loudoun County is minimal in comparison to other alternatives because of the high cost of pumping, treatment and conveyance that would be required.

To obtain the benefit of economy of scale, an aggregation of communities using this type of scheme would appear more feasible than one which involved separate pipelines for individual communities. Because of the uncertainty regarding regionalization in this area, pumping schemes were not developed. Other difficulties involving pumping from the Potomac River are discussed the following section on Fairfax City. The conclusions represented in this section are also applicable to communities in northern Loudoun County.

Inspection of Figure I-15 for the Fairfax City Service Area reveals that additional water (on the order of 4.7 billion gallons) would be needed over a six month period if a repeat of the 1930 drought were to occur with projected year 2030 demands. Because both the Goose Creek and Beaverdam Reservoirs are drained under this scenario, about a 30 to 40 mgd raw water pumpover from the Potomac River to the Beaverdam Reservoir and Goose Creek Water Treatment Plant would be required to avert shortages. Figure I-38 illustrates one potential configuration for such a pumpover.

The Potomac River to Beaverdam Creek raw water interconnection is approximately eight miles long. The route begins at the VEPCO OTL clearing approximately one-half mile downstream from Harrison Island. It follows the OTL clearing in a southwesterly direction until it intersects Route #643 then bends southeast and follows Route #643 until it intersects with Route #659. At this intersections, the route bends south and follows Route #659 for approximately one mile then bends directly west and travels across open country to Beaverdam Creek. The by-pass line to the Fairfax City Water Treatment Plant begins at the intersection of Routes #659 and #643. The line travels north on Route #659 for approximately 4,000 feet to the treatment plant.

Using the MAPS computer program described earlier, rough capital cost estimates were developed for the Potomac-Beaverdam Reservoir raw water interconnection (Table I-35). Table I-36 lists the important assumptions which were used as input to the computer model to derive the capital costs. It is noted that these costs are derived in part from generalized cost curves and more site specific methods would be required to develop a more accurate estimate of this scheme.

Table I-35

POTOMAC RIVER - BEAVERDAM RESERVOIR

RAW WATER INTERCONNECTION COST ESTIMATE[1]

Required Flow (MGD)	Pipeline[2] Cost ($Mill)	Pump Station[3] Cost ($Mill)	Total Cost ($Mill)
30	9.65	2.13	11.78
40	9.65	2.92	12.57

[1] Capital Cost in October 1981 dollars.
[2] 36 - inch pipe based on cost-effectiveness. Larger line might be required depending upon frequency of use.
[3] Pump station cost does not include cost for intake.

Figure I-39, which is reproduced here from Figure D-39 Appendix D - Supplies, Demands and Deficits, demonstrates the limitations of a Potomac-Beaverdam interconnection. During the same period of shortages in the Goose Creek basin, Potomac flows in the Washington area would also reach critically low levels, given a flowby of 100 mgd and the major Potomac users operating their facilities per their regional agreements. Since the Occoquan Reservoir water treatment facilities would be operating at, or near, their maximum capacity during this same period, there would exist little, if any flexibility

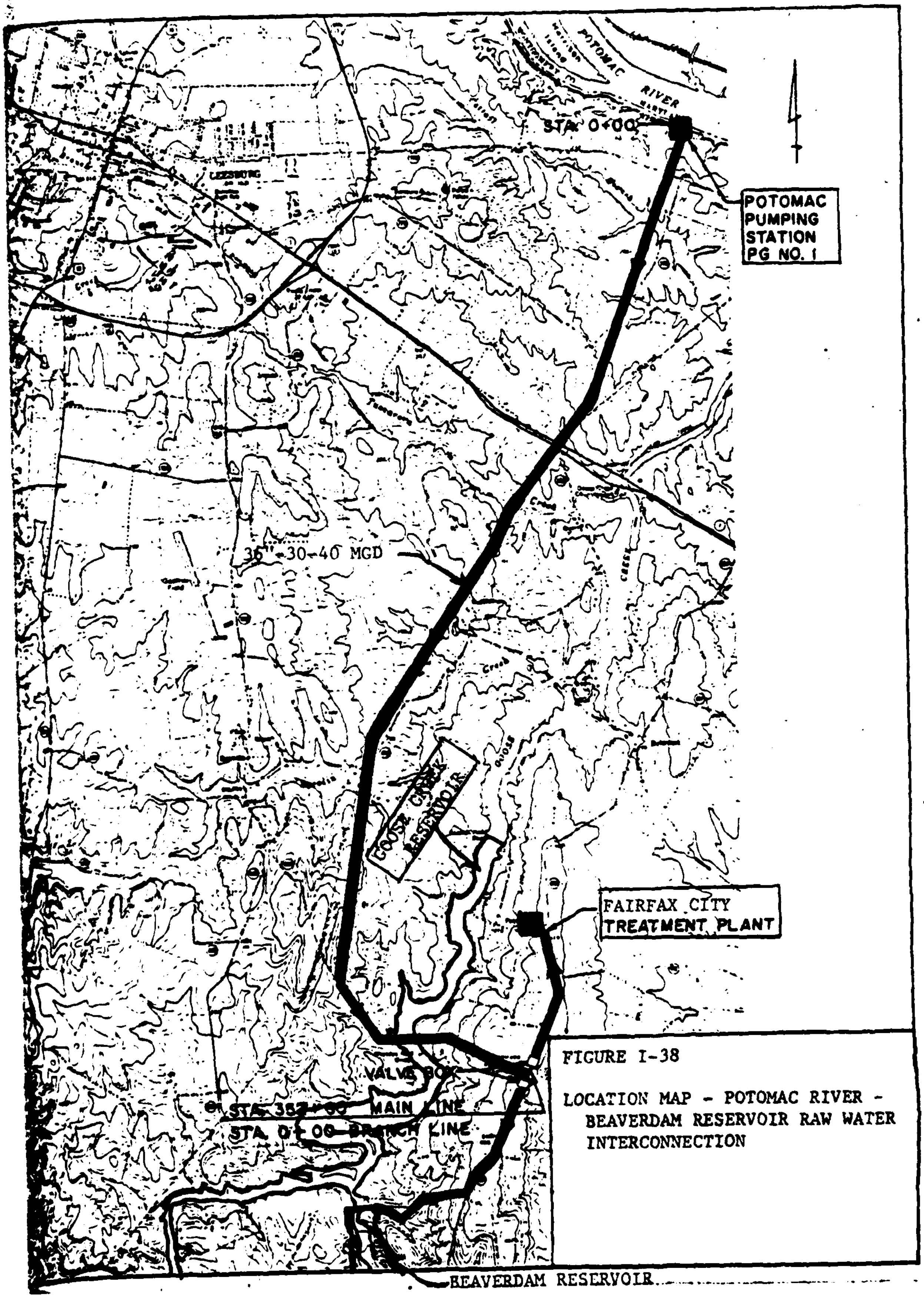


FIGURE I-38

LOCATION MAP - POTOMAC RIVER - BEAVERDAM RESERVOIR RAW WATER INTERCONNECTION

FIGURE I-39

SIMULATED POTOMAC RIVER HYDROGRAPHY

WITHOUT CONDITION - 100 MGD FLOWBY

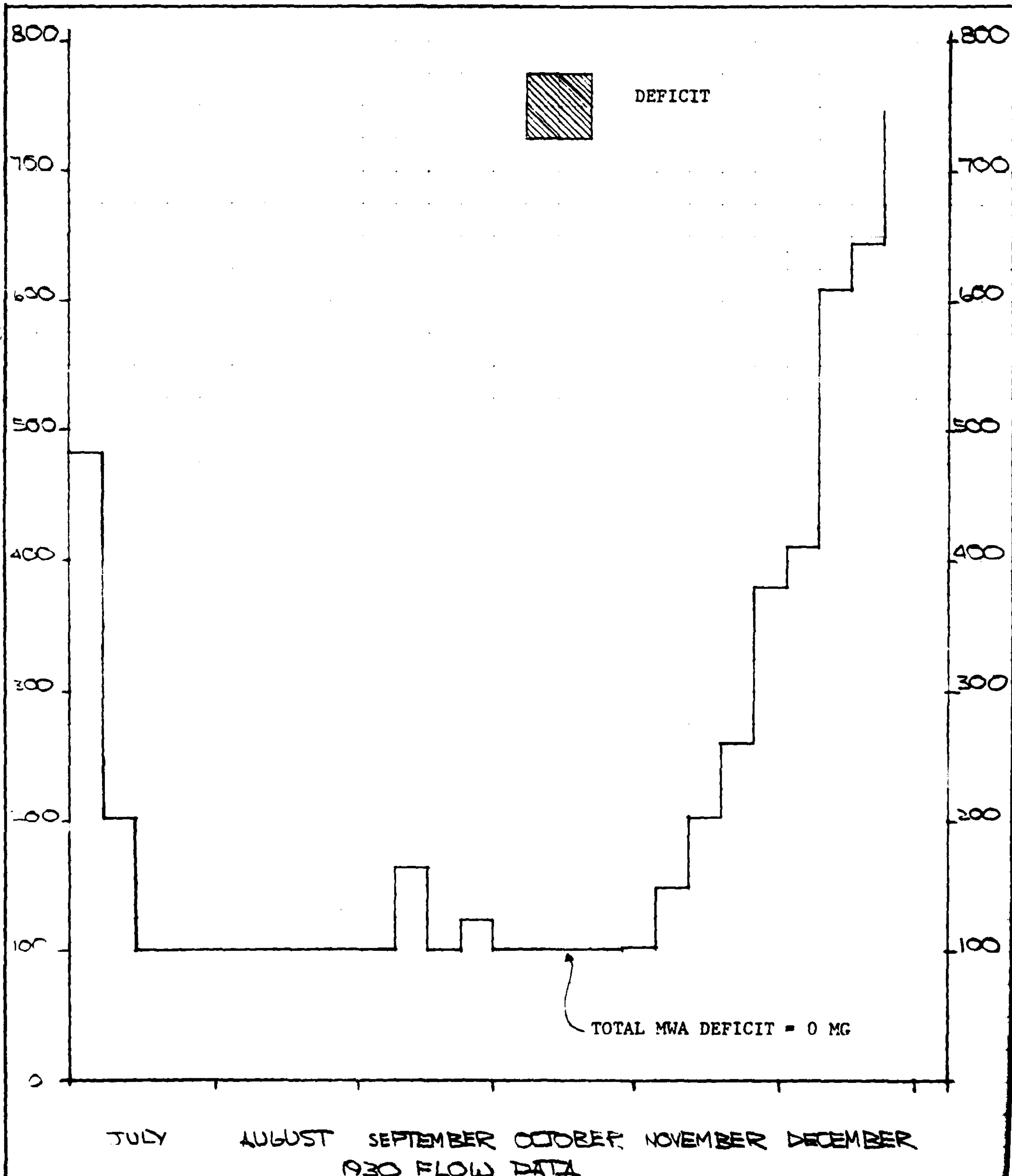


Table I-36

POTOMAC RIVER - BEAVERDAM RESERVOIR
RAW WATER INTERCONNECTION MAPS
INPUT DATA

Pipeline Length (FT)	46,300
Inital Elevation (FT)	182
Final Elevation (FT)	423
Peak Elevation (FT)	465
Distance to Peak (FT)	23,200
Construction Year	1981
Interest Rate (%)	7.625
Design Life (YRS)	50
Pump Efficiency (%)	80
Pipe Type	Steel
Land Cost ($)	
Land Type	50% open country 50% sparse residential

within the regional system to allow for an additional 30 to 40 mgd withdrawal from the Potomac River for Fairfax City without incurring proportional deficits for the major Potomac users. Any scenario involving higher flowby levels would proportionately increase this risk. Recognizing the delicate balance between flowby, withdrawals, and deficits which exist in the MWA under this future scenario and given the fact that the major Potomac service areas have entered into regional agreements to ensure that this balance is not compromised, it would be very difficult from an institutional and implemention standpoint to justify a new 30-40 mgd intake in the Potomac for the Fairfax City Service Area given the others alternatives which are possible for this area.

SUMMARY OF MAJOR FINDINGS

The study determined that population growth and water demands are expected to rapidly increase in the outlying portions of MWA, in fact, more than the urban core areas which are projected to have much slower rates of growth. Based upon a demand projection model developed for the Corps of Engineers which used population, socio-economic, water use data, and an estimation of the phasing of areas to be served by public systems, average annual demands were projected to grow to approximately 37 mgd for both the Fairfax City Service Area and Loudoun County Service area, 20 mgd for the Prince William County area and about 13 mgd for the Charles County service area by the year 2030.

A review and survey of existing facilities was conducted for the present study for each service area. Based on present supplies and facilities and the projection of demand it was concluded that the outlying areas would be unable to meet the projected needs. Although exceptions to this may be possible in individual communities, service area projected demands exceed the level of supplies presently available and expected to be developed in the near future.

Numerous planning and technical reports were reviewed which have been prepared by other agencies and their contractors for the outlying areas. Although no study for any area has dealt with a 50-year planning horizon as does the MWA study, three major categories of projects have been most often recommended for meeting needs in the outlying areas. These include reservoirs, groundwater, and interconnections.

It was concluded that the regionalization of supplies within or between service areas would enable these areas to make better use of available supplies however this would be limited by a finite water supply base. Additional supplies are warranted although the degree of development will vary for area to area.

Nine alternatives were reviewed for their potential and applicability to the outlying areas (Table I-37). These alternatives were organized into two categories; those which were essentially non-structural or maximize the use of existing levels of supplies and those which involve additional supply development. Table I-38 summarizes the degree by which each alternative could be applied to the service areas investigated. It is noted that certain measures could be applied uniformly to all areas, i.e., conservation and pricing, whereas other measures are only applicable to locations or sub-areas within a service area i.e., Potomac River pumpover is possible for northern Loudoun County or Fairfax City only. This table is not intended to demonstrate how well these measures could perform in these areas, but rather, where they could reasonably be applied.

Table I-39 provides a general summary assessment of the alternatives considered in the outlying service areas. The indicators in the matrix show on a relative scale the degree by which the alternatives meet the criteria which are set. "H" represents that the alternative is highly likely to meet the criteria, "M" represents a medium likelihood, and "L" little if any likelihood. For example, reservoirs have a high likelihood to meet water supply needs, create significant impacts, can be used for a multiplicity of purposes in addition to water supply, have a medium potential to be staged over time, and have, in most areas investigated, a low possibility for implementation due to the general sentiment against impoundments in the northern Virginia area. The following statements highlight the major finding for each alternative based in part from Table I-39 and from other parts of this report.

TABLE I-37

SUMMARY LIST OF ALTERNATIVES

I. MAXIMIZE USE OF EXISTING RESOURCES
- Water Conservation
- Pricing
- Interconnect and/or Purchase from Existing Systems

II. WATER SUPPLY DEVELOPMENT - AUGMENTATION
- Reservoirs
- Groundwater
- Water Treatment Plant Expansions
- Use of Potomac Estuary
- Wastewater Reclamation
- Potomac River Pumpover

TABLE I-38

APPLICABILITY CHART - OUTLYING SERVICE AREAS

MEASURES	Service Areas: FAIRFAX CITY	LOUDOUN CO.	PRINCE WILLIAM CO.	CHARLES CO.
Water Conservation	1,2	1,2	1,2	1,2
Pricing	1,2	1,2	1,2	1,2
Interconnect				
Within Svc Area	3	2	1,2	1,2
To Adjacent Svc Areas	1,2	2,3	2	2
Reservoirs	1	1,2	1,2	2
Groundwater	1	1,2	1,2	1,2
WTP Expansions	1	1,2	1,2	1,2
Potomac Estuary	3	3	1,2	1,2
Wastewater Reclamation	1,2	1,2	1,2	1,2
Potomac River Pumpover	1	2	3	3

1 = Could be applied to entire service area.
2 = Could be applied only to sub-areas within individual service area.
3 = Little or no application to either entire service area or sub-areas.

1. Water Conservation: Assists in demand reduction and thus could result in a delay or reduction in size of structural projects. Water conservation will not in itself eliminate the need for additional supplies but is recommended for use in conjunction with any source which is developed.

2. Pricing: Near term demand forecasts would not be further reduced by better pricing policies because of the high proportion of fixed costs for these utilitites and the small escalation of long run marginal cost for water in these areas.

3. Interconnections: Interconnecting finished water systems within the outlying service areas or between these areas and adjacent systems will not augment the region's water supply base. This concept does however enable areas to make more efficient use of available supplies and distributes any geographic inbalance of supply and demand which may exist. Perhaps the greatest potential for interconnections would be to allow reserves such as groundwater to be recharged and saved for emergency use by providing a means by which these areas could rely on more water "rich" areas during non-drought periods.

TABLE I-39

ALTERNATIVES ASSESSMENT

ALTERNATIVES	CRITERIA: POTENTIAL TO MEET WATER SUPPLY NEED: INDIVIDUAL SUBAREA	ENTIRE SERVICE AREA	RELATIVE COST OF DEVELOPMENT $/UNIT VOLUME	DEGREE OF ADVERSE IMPACTS: ENV	SOC	CULTURAL RESOURCES	MULTIPLE USE POTENTIAL	RELIABILITY	INCREMENTABILITY (STAGING POTENTIAL)	EASE OF IMPLEMENTATION
WATER CONSERVATION	L	L	L	L	M	L	L	M	H	M-H
PRICING	L	L	L	L	M	L	L	L	M	M
INTERCONNECT										
WITHIN SERVICE AREA	M	M	M	M	M	M	L	M	M	M
TO ADJACENT SERVICE AREAS	M	M	M	M	M	M	L	M	M	L-M
RESERVOIRS	H	H	M	H	H	H	H	H	M	L-M
GROUNDWATER	H	M	M-H	M	M	H	M	M	H	M-H
WTP EXPANSIONS	L	L	M-H	L	L	L	L	H	H	H
POTOMAC ESTUARY	L	L	UNKNOWN	H	H	H	L	UNKNOWN	M	L
WASTEWATER RECLAMATION	L	L	H	M-H	M-H	M	M	L	M	L
POTOMAC RIVER PUMPOVER	M	L	M-H	M-H	M-H	M	L	L	M	L

L - Low Potential
M - Medium Potential
H - High Potential

4. Reservoirs: Reservoirs have the greatest potential of all of the alternatives considered to meet future needs at all levels of regionalization. The exception to this is in the Charles County service areas because of the lack of adequate natural sites. Reservoirs however, create significant environmental and social impacts. In the past, there has been great resistance to the development of reservoir sites in Loudoun County where the greater abundance of potential sites are located. Significant economics of scale are achievable with reservoirs.

5. Groundwater: Groundwater development is possible in all of the outlying service areas; however, the potential for development is greatest in the Triassic Lowland and Coastal Plain. Large scale development of well fields is more costly, less reliable, and more likely to impact existing wells in the area than the development of small well fields for a restricted number of users. Much additional field testing would be required to accurately determine the yield potential at any given location. Environmental and social impacts for well field development would generally be much less severe than those expected for reservoir development.

6. Water Treatment Plants: Either new or expanded water treatment will be required to meet the projected needs in the outlying areas. Full scale filtration for a surface water source is significantly more expensive than chlorination which would be the only required treatment of groundwater in most cases.

7. Potomac Esturary: The Prince William and Charles County service areas are adjacent to the Potomac estuary at about 10 to 15 miles south of the present Potomac Pilot Estuary Water Treatment Plant. Results of the pilot plant testing program cannot be reasonably extended to these areas because of the significantly different salinity, biochemical, and physical relationships which exists at these locations. The potential lack of economy of scale and public acceptance constitute two additional problems for this alternative in these areas.

8. Wastewater Reclamation: Recovery after land application as well as other reuse strategies have limited potential as potable water supply alternatives. Since commercial/industrial uses average only between 10 and 12 percent in these areas (these uses may or may not require a potable source) non-potable reuse is also limited. Recharge of aquifers via land application or wastewater well injection does not appear feasible due to stringent health regulations regarding the use of contaminated groundwater sources.

9. Potomac River Pumpover: Potomac River raw water pumpovers are suited for areas in northern Loudoun County in conjunction with high flow skimming reservoirs. A pumpover to the northern Loudoun County communities would be costly and would not benefit from economic of scale based upon the present organization. The greatest limitation of a pumpover to the Fairfax City system is that in time of greatest needs, available flows in the Potomac River are most limited. Any additional sizeable withdrawal from the Potomac River during critical low flow periods will affect the ability of the major Potomac River users to meet the balance of water supply and flow-by which will be required in the future.

WATER SUPPLY PLANNING
STEPS FOR OUTLYING SERVICE AREAS

The preceding portions of this Appendix discussed the existing situation, in each of the outlying service areas, with regard to water supply. Some of the communities in these areas are small, with low densities of development and are generally adequately served with groundwater for water supply. Others are much more densely populated and have greater need for water supply and expanded facilities. In addition, there are some localized problems in other communities, such as falling groundwater tables in Round Hill, Virginia.

This portion of Appendix I will deal with water supply planning for a "typical" service area or communities within a service area. This "typical" area is not meant to represent any community in the outlying service areas, nor is it meant to provide a solution for any particular community. Rather, its purpose is to set forth principles involved in planning for such communities, and to provide some insight into the processes which might be involved in developing a dependable water supply in these areas.

A rational approach to planning within the outlying service areas could consist of the following steps:

1. Demonstrate need for action (define problems);
2. Establish broad alternatives to existing supply levels;
3. Develop preliminary designs for project alternatives;
4. Evaluate alternatives;
5. Recommend course of action.

This procedure may be viewed as an iterative one in which the entire process may be executed several times. A brief discussion factors to be considered in each of the above planning steps follows.

STEP 1 - DEMONSTRATE NEED FOR ACTION

Problem definition is an essential part of the planning process, since a proposed project with a poorly demonstrated need will receive neither financial support from the government nor popular support from the community. Need could fall into one or more of the following categories:

Past and Future Shortages: Based on the history of well failures, reservoir depletion or drawdown, frequency of implementing emergency conservation measures and an appreciation of the likelihood for these events to repeat themselves in the future it can be reasonably concluded if action is needed. The projection of future growth may also suggest that present supply capabilities will have to be expanded to accomodate future needs.

Public Health: Poor and degrading water quality of existing sources may prompt the need to develop more dependable and better quality sources of supply. Groundwater

contamination, and poor quality surface supplies due to non-paint run-off may be special problems in some areas.

Economic: In certain cases, the economic burden of maintaining existing sources at a dependable and safe level is great. Alternate sources may be preferable in these situations.

Community Goals and Desires: This involves the desire and plans that a community or planning board has for future growth in a given area. Plans to accommodate and provide industrial and commercial development or high residential growth must be complimented by planning for additional water to meet new requirements. On the other hand, a "no growth" or restricted growth philosophy might imply very stringent regulation of development of supplies and the extension of water supply facilities to new areas.

The remainder of this discussion will assume the area in question has demonstrated on a preliminary basis, the need for additional supplies. Alternative courses of action can each be analyzed under the stepwise process discussed below for the range of communities which exist in the outlying service areas.

STEP 2 - ESTABLISH BROAD ALTERNATIVES TO THE EXISTING LEVELS AND TYPES OF SUPPLY

Any water supply system could consist of a variety of sources such as those listed in Table I-37. For each area or sub-area, there are alternatives which could be considered further or eliminated based on a rough knowledge of their geographic applicability (e.g., Table I-38), the scale of the system involved, generalized cost, local site conditions and project objectives. Examples are:

Conservation: Can be applied everywhere; however, the degree of reduction achievable is dependent on user characteristics and amount of user participation.

Groundwater: Low well yields in existing aquifers (e.g., Blue Ridge) will minimize the amount of further development of these resources in the future. Full scale development in areas of existing heavy use may jeopardize existing wells. Estimates of additional supplies based on existing information (USGS) can be supplemented with additional testing to determine full potential of groundwater resource.

Reservoirs: Size of drainage area, water quality, natural environment land use, safe yield, site conditions will all determine the potential for a dam and reservoir at any given location.

Interconnections: Physical proximity, characteristics and condition of existing finished water distribution infra-structure, reliability and supply capacity of "source" system will be important.

Unless site conditions dictate otherwise, it is well to consider at least some widely varying alternatives such as those above as well as others. Further analysis may reveal potential additional benefits unknown at these earlier stages of planning.

STEP 3 - PRELIMINARY DESIGN OF ALTERNATIVES

Once broad alternatives have been established for each area of subarea, these component alternatives can be combined to establish preliminary system designs. As a basis of design, water demands are projected to future years to allow for sizing of system elements. Demand projections should consider the nature and character of use to improve the accuracy of the demands and to define the best type of supply to be provided. Based on those projections, staging of water supply and water treatment plant capacities are estimated, and the staging levels for benchmark years can be determined. This evaluation should allow the comparison of local versus regionalized systems which used a central source or interconnected sources.

Included in the systems design are not only the sizing of all capital works, but also operating requirements for each alternative, such as operating and maintenance labor, chemicals, replacement parts, power requirements, and operating schedules, should be site-specific, to allow for variability in the estimates of costs for land, drilling conditions, and other contigencies.

Figures I-25 and I-26 and Figures I-28 through I-37 provide a starting point in developing size and cost estimates of potential facilities. However, the project design must be site-specific to allow for the variability in the estimates of cost with location. Subsurface geology, topographic conditions, water quality, property rights, and safe yield will all come into play in design of a reservoir project. In the case of groundwater, the true groundwater potential via test wells must first be determined the optimum degree of drawdown and yield which can be achieved. Minimization of impact on nearby wells must also be considered, as well as groundwater quality. The character of water use (e.g., industrial, commercial, residential) well dictate the extent and type of conservation program most adaptable in individual areas.

STEP 4 - EVALUATION OF ALTERNATIVES

The evaluation of alternatives should consider economic, environmental, and social concerns. The economic evaluation has as its major purpose the determination of which alternative is the most cost-effective. The cost-effective solution can be roughly defined as that alternative which accomplishes the criteria and objectives for the project at the least total cost. One way to measure the total cost, for comparison purposes, is to calculate the present worth of all capital, operation, and maintenance costs, initial and future.

Impacts on the natural environment can fall under numerous categories, such as surface water, groundwater, land, air, terrestrial ecology, and aquatic ecology. Each alternative will have some impact on each of these, and the environmental assessment is an attempt to both define these impacts in such a way that the most desirable alternative can be determined, and also to suggest means to mitigate or eliminate avoidable impacts. Short-term impacts can be differentiated from long-term ones, and irretrievable commitments of resources can also defined.

Social and socio-economic impacts will be critical for determining the implementability of a given alternative. This is particularly true for the study area where the costs the project are likely to be born entirely by the users. Therefore, the opinions of the

community should be solicited during the conduct of the study. Also, an institutional evaluation should be done to determine a likely implementing agency; the ability of the area to organize, reach decisions and enforce them, the ability of the organization to tax, secure bonds etc. In cases where the cost of a regional system is greater than the cost of individicual residential wells, a loss of disposable can result which can be significant in small communities.

STEP 5 - RECOMMEND PLAN OF ACTION

The net result of the process outlined in the above steps should be a single or combination of alternatives which meet all legal criteria, is cost-effective, and attains the best balance of meeting community goals and avoiding adverse environmental impacts. This alternative then becomes the recommended plan of action.